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Full-Scale Study of Sequencing Batch Reactors

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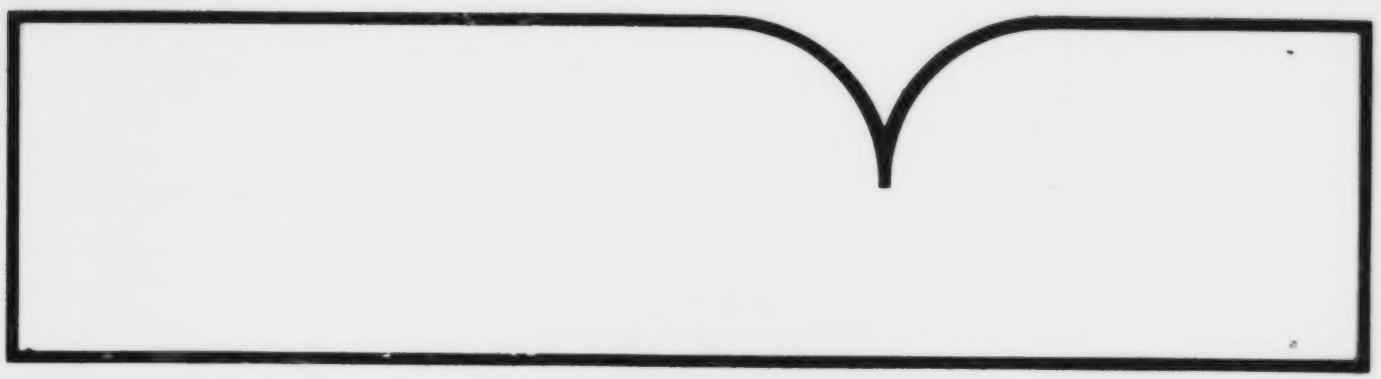

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FULL-SCALE STUDY OF SEQUENCING BATCH REACTORS

by

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Grant No. 806598

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16. ABSTRACT

A conventional activated sludge system owned and operated by the Town of Culver, Indiana was converted to a two-tank Sequencing Batch Reactor (SBR) treatment plant. The average flow during SBR operation was 1340 m^3/d. The loadings varied from 0.2 to 0.4 kg $BOD_5/d/kg$ MLVSS on an aeration time adjusted basis and the sludge age ranged between 15 and 45 d. During the first year of SBR operation (May 1980 to May 1981), the effluent BOD_5, SS and phosphorus concentrations averaged less than 10 g/m^3, 8 g/m^3 and 0.5 g/m^3, respectively. Phosphorus was removed chemically by adding either ferric chloride or alum. Nitrogen was removed biologically after blower malfunctions were remedied during the late spring of 1981. Between August and December 1981, effluent BOD_5, SS and phosphorus levels were similar to those achieved during the first year while effluent ammonium and nitrite plus nitrate nitrogen concentrations were 1.1 g/m^3 and 1.3 g/m^3 respectively. Overall 90% of the inorganic nitrogen was removed biologically. As a result of the demonstration study, the SBR was shown to be a viable alternative to conventional continuous flow activated sludge treatment of domestic wastewaters for BOD_5 and SS removal, nitrification, denitrification and chemical precipitation of phosphorus.

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FOREWORD

The Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment, and management of wastewater and solid and hazardous waste pollutant discharge from municipal and community sources, for the preservation and treatment of public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic efforts of pollution. This publication is one of the products of that research; a most vital communications link between the researcher and the user community.

This effort describes the conversion of a continuous flow activated sludge facility to a sequencing batch system for treatment of municipal wastewater.

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ABSTRACT

This report presents an operating summary of a full-scale demonstration of a two-tank Sequencing Batch Reactor (SBR) activated sludge treatment plant. The study was conducted over a period of 20 months at the facilities of the Town of Culver in Indiana. The average flow during SBR operating periods was 1340 m^3/d, the loading varied from 0.2 to 0.4 kg BOD_5/d/kg MLVSS on an aeration time adjusted basis and the sludge age ranged between 15 and 45 days. Phosphorus was removed chemically by adding either ferric chloride or alum.

The SBR operated on a fill and draw basis. One tank received the primary effluent while the other tank completed treatment, sedimentation and discharge. The two tanks at Culver alternated roles throughout the day with each tank undergoing approximately four fill and discharge cycles each day. Operational changes were controlled by a process controller.

Conversion of the conventional continuous flow facility at Culver to the SBR mode of operation was completed by May 1980. Between May 1980 and May 1981, the effluent BOD_5, SS and phosphorus concentrations from both tanks averaged less than 10 g/m^3, 8 g/m^3 and 0.5 g/m^3 respectively. Because of dissolved oxygen limitations, nitrification was not observed during this period. An electronic control system failure and excessively high flow rates interrupted SBR operation between late May and mid August 1981. SBR operation from August to December, 1981 achieved similar effluent BOD_5, SS and phosphorus as above; as well as effluent ammonium and nitrite plus nitrate nitrogen concentrations of 1.1 g/m^3 and 1.3 g/m^3 respectively. Biological nitrogen removal of inorganic nitrogen during this period was roughly 90%.

In addition to allowing an evaluation of the SBR system, the demonstration provided an opportunity to investigate various equipment components as to their general reliability and performance.

This report was submitted in fulfillment of Grant Number R-806598-01-3 sponsored by the United States Environmental Protection Agency. The report covers SBR conversion analysis and plant performance data for the period April 1, 1979 to December 31, 1981.

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Many people contributed to the successful operation of this first SBR treatment facility but only two were essential. The first, Mr. Robert Breyfogle, Superintendent of the Culver, Indiana Wastewater Treatment Plant, contributed what seemed to be untiring and unending input to all phases of design, conversion and operation. The second, Mr. Steven C. Chiesa, graduate student at the University of Notre Dame (now Assistant Professor at the University of Minnesota), worked with Mr. Breyfogle in each of these phases translating the theory from the University to the performance of the treatment plant. We all give our thanks to these two.

SECTION 1

INTRODUCTION

During the mid to late 1970's research and development at the University of Notre Dame's environmental engineering laboratories focused on biological treatment of wastewaters in periodically operated reactors. Results revealed that these systems could become a viable alternative to conventional continuous flow activated sludge treatment facilities. Full-scale operating experience from Australia and Europe on similar periodic systems supported this view. Unfortunately because of the virtual complete absence of an operating periodic system in the United States, expectations for early use of such systems in this country was low.

The United States Environmental Protection Agency (USEPA) recognized both the potential value of the Sequencing Batch Reactor (SBR, the periodic system developed at the University of Notre Dame) for the treatment of municipal wastewaters and the need for full-scale operating experience before the SBR could be accepted as a viable treatment alternative. As a result, the USEPA funded a full-scale demonstration study beginning April 1, 1979.

A conventional continuous flow activated sludge treatment plant owned and operated by the Town of Culver some 45 miles southwest of Notre Dame in Indiana was selected as the demonstration site. A schematic for the Culver facility, general plant information and a summary of pre-SBR conversion operating data are given in Figure 1 and Tables 1 and 2 respectively. Typical preconversion operation involved use of either the comminuter or bar screens, followed in order by the grit chamber, two of the three primary clarifiers, one of the two aeration tanks, both secondary clarifiers and the chlorine contact chamber. Sludge was wasted to both aerobic digesters. As can be seen from Table 2, treatment performance at Culver was excellent prior to SBR operation.

SBR operation began in May 1980 and continued essentially uninterrupted until late May 1981 when extended periods of record high flows and irreparable breakdown in the microprocessor control system forced a changeover to a modified continuous flow mode. A new control system was installed in August 1981. SBR operation continued throughout the remainder of the report period.

A brief summary of findings, conclusions and recommendations for the Culver facility is presented in this Final Report. A much more extensive analysis of Culver operating data as they impact on future SBR design and operation may be found in an USEPA Emerging Technology Assessment Report.

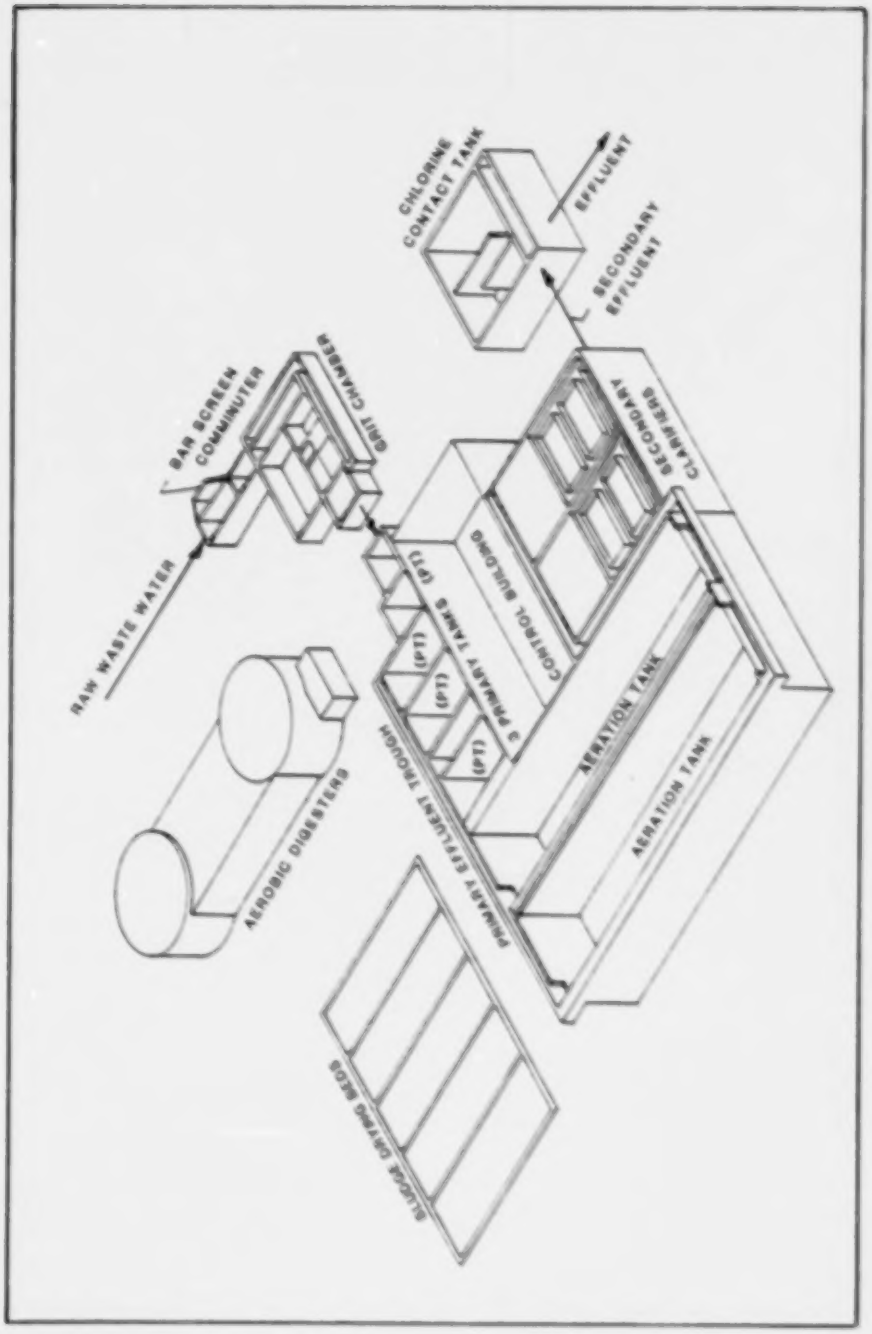

FIGURE 1. Culver Plant Schematic

TABLE 1. General Plant Information

Yearly Average Flows:

1977: 1170 m^3/d

1978: 1120 m^3/d

1979: 1170 m^3/d

Tank Volumes:

Three Primary Clarifiers:	65 m^3	each
Two Aeration Tanks:	460 m^3	each
Two Secondary Clarifiers:	130 m^3	each
Chlorine Contact Chamber:	65 m^3	
Two Aerobic Digesters:	570 m^3	each

Approximate Loading:

0.2 kg BOD_5/kg MLSS-d

Type of Aeration:

Two 45 kW Centrifugal Blowers

Course Bubble Diffusers

Capacity of Blower:

0.6 m^3/s

TABLE 2. Summary of Preconversion Operating Data - Yearly Average Concentrations

	Raw Waste	Primary Effluent	Final Effluent
BOD_5[†], g/m^3			
1977	140	90	6
1978	150	110	7
1979	150	90	7
SS, g/m^3			
1977	140	60	5
1978	150	100	5
1979	110	60	5
Phosphorus, g/m^3-P			
1977	3.5	-	1.0
1978	6.4	-	1.1
1979	7.4	-	1.0
NH_4-N plus NO_x-N[††], g/m^3	31	-	25

SVI (mℓ/g) averaged 200 between 1977 and 1979.

[†]Post Chlorination for Final Effluent.

[††]Average for November and December 1979 only.

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

One major conclusion resulted from the study conducted at Culver: the SBR is a viable alternative to conventional continuous flow activated sludge treatment of domestic wastewaters for BOD_5 and SS removals, nitrification, denitrification and chemical precipitation of phosphorus. Specific conclusions that can be summarized include the following:

1. Effluent limitations of 10 g/m^3 BOD_5 and 10 g/m^3 SS are easily met with an SBR.

2. Effluent ammonium nitrogen concentrations less than 1 g/m^3 are also easily achieved with an SBR.

3. Nitrification and denitrification took place simultaneously during FILL and REACT.

4. The time in FILL (2) and the total time under aeration (FILL (3) plus REACT) are more important to system design and operation than either sludge age or organic loading.

The SBR at Culver was generally easy to operate and as the treatment plant operator put it "more forgiving than the continuous flow system." In other words, effluent quality was reasonably insensitive to oversights that sometimes occur during normal operation. As can be seen from the SBR and continuous flow data, oversights were not frequent at Culver and excellent operational control was maintained.

Other than the necessary mechanical developments that can be made in inlet, outlet and control devices, the major recommendations can be summarized as follows:

1. The maximum organic loading which can produce an effluent quality of 30 g/m^3 for both BOD_5 and SS should be determined for the SBR.

2. Control strategies which allow biological phosphorus removal in an SBR should be investigated.

SECTION 3

BRIEF SUMMARY OF RECENT LITERATURE

Two works which became available during the past few months, a thesis by Burke (1) and a presentation by Barth (2), provide both a description of the SBR and an historical perspective of SBR use. A presentation by Goronszy and Irvine (3) gives a summary of an intermittent system used in Australia and early performance data for the SBR facility at Culver. Pasveer (4) developed the use of periodic systems in the Netherlands. Denmark, however, is the only European country using periodic systems on a large scale at this time (5). A general discussion of the use of SBRs in a wide variety of application areas may be found in a conference proceedings edited by Irvine (6). Finally, the February, 1979 issue of the Journal Water Pollution Control Federation featured a series of seven articles (7,8,9,10,11,12,13) which collectively provide a broad overview of periodic systems and their use.

SECTION 4

HYDRAULIC DESCRIPTION OF SBR

Perhaps the simplest way to describe the SBR is to consider the actual operation of the Culver facility. At Culver, with the exception that only one instead of two primary clarifiers was used, the flow through the comminuter, screens, grit chamber and primary tank was left unaltered from the continuous flow operation. The two secondary clarifiers and chlorine contact chamber were not required for SBR operation and were left untouched with SBR effluent simply passing through these tanks for discharge to the receiving water. Return sludge pumps are not used during SBR operation. The major components of the SBR are the two aeration tanks which are designated the North Tank (NT, nearest to the control building) and the South Tank (ST). These two tanks sequentially provide partial load equilization while cycling as the biological reactor and sedimentation tank.

After conversion to SBR operation, each aeration tank underwent approximately four cycles every day with each cycle divided into five major periods: FILL, REACT, SETTLE, DRAW and IDLE. Primary effluent entered one tank, or the other, on an alternating basis during FILL. The remaining four periods were carried out without the addition of primary effluent. The full operation is discussed below.

Daily operation was conceptually rather simple and can be followed by referring to Figure 2. Primary effluent was directed to either the North Tank or the South Tank during the period of the cycle called FILL. When one tank, say NT, was filled to the maximum liquid level, the primary effluent was diverted to ST. Treatment initiated during FILL in NT continued, without

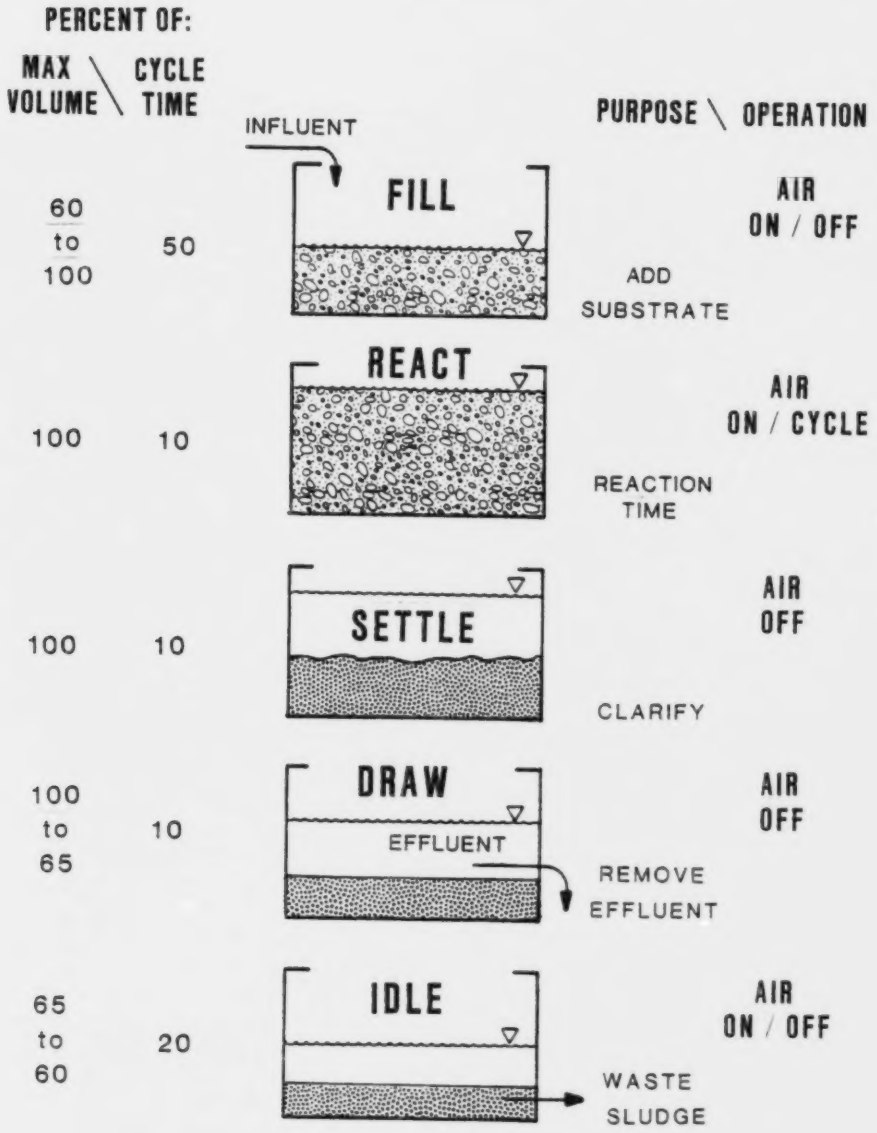

FIGURE 2. Approximate SBR Operation for One Cycle at Culver

additional feed, during REACT. After REACT, the mixed liquor suspended solids (MLSS) were separated by quiescent sedimentation in this north aeration tank, in a period designated SETTLE. After SETTLE, the treated effluent was pumped through a specifically designed chlorination box before discharge to the stream during DRAW. When the other tank, ST, completed FILL, primary effluent was redirected to NT and the full cycle was repeated. The time between the end of DRAW and the beginning of FILL was labeled IDLE. Sludge wasting at Culver took place during IDLE once each day in each tank. In summary: one tank underwent REACT, SETTLE, DRAW and IDLE while the other was in FILL with each tank alternating roles throughout the day. Since each tank underwent approximately four complete cycles each day, a total of eight FILL periods occurred each day.

Between May 1980 and April 1981, information on times for each cycle for each tank was collected on 256 separate days for the North Tank and 257 for the South Tank. A summary of average times (rounded) for each period in one cycle is presented below:

	North Tank (hours)	South Tank (hours)
FILL	2.9	3.1
REACT	0.7	0.4
SETTLE	0.7	0.7
DRAW	0.7	0.7
IDLE	1.0	1.1
TOTAL	6.0	6.0

These data are included in Figure 2 along with the approximate volume changes for each tank at Culver.

As can be seen from the summary of average times above, one tank completed REACT, SETTLE and DRAW in less time than the other needed for FILL. On some specific occasions, however, one tank would complete FILL before the other finished DRAW. This occurred on 18 days for NT (out of 256) and 14 for ST (out of 257) for an average of two minutes for each six hour cycle. During such instances, primary effluent would enter the tank as required but discharge continued until the minimum liquid level was reached. Only after the discharge pump shut-down did mixing or aeration begin. The overlap of FILL and DRAW was designated FILL (1). The averaging overlap time for the total 32 FILL (1) event days was 29.5 minutes, with times of 60 minutes or more occurring on only 3 days. As a result, FILL (1) was only used as an operational convenience at Culver.

Because of flow variations both within a day and between months, level sensors used to control plant operation were adjusted as needed. The variations and adjustments accounted in part for the overall average differences in times shown above for both tanks. Such differences are even more pronounced on a monthly and daily basis. Average total daily times for

eleven individual months are given in Tables 3 and 4 for NT and ST respectively. Complete daily operating data are given in Appendix I.

As can be seen from Tables 3 and 4, FILL was divided into three discrete periods (the common element being primary effluent flow into the reactor), FILL (1), as discussed above, and FILL (2) and FILL (3). A typical cycle began with FILL (2), a mixed but unaerated period, followed by FILL (3), a mixed and aerated period. As is shown in Table 5, FILL (2) comprised (on the average) 30% of the total time in FILL in NT and 40% in ST with the range for both tanks being 13% in April 1981 to 51% in May 1980. Because of differences in level switch locations, ST received more primary effluent than NT during an average 24 hour period. Variation in total FILL time from monthly average to monthly average for a given tank was generally less than 5% with the difference between the minimum and maximum reported times being approximately 10%. A final factor worth noting is the total time during a 24 hour period that the mixed liquor was under aeration. This corresponds to the time in FILL (3) plus the time in REACT. Interestingly, only 37% of an average day was dedicated to aeration in ST and 45% in NT. This is a process consideration and is discussed in more detail in the next section.

SECTION 5

PROCESS DESCRIPTION OF SBR

Process considerations can be reduced to two levels: (1) mixed liquor settleability and (2) completion of necessary reactions. Bench-scale studies had indicated that anoxic FILL periods were necessary to control the impact of filamentous organisms on the settling rate of the mixed liquor suspended solids (MLSS). As a result, FILL (2) (mixing without aeration) was added to the overall operational scheme. The manner by which FILL (2) controls reactions within the microorganism system to adjust physiological states which, in turn, defines organism morphology (and, therefore, settling rates) is not known. As a result, process considerations as related to the completion of necessary reactions was limited to: (1) removal of five-day biological oxygen demand (BOD_5) and suspended solids (SS), (2) nitrification, (3) denitrification and (4) chemical phosphorus removal.

The simplest aeration policy is, of course, to aerate throughout FILL and REACT. This policy has consistently led to settling problems in laboratory reactors. Low substrate tensions resulting from low substrate feed rates seem to favor the growth of filamentous organisms. FILL (2) mitigates this difficulty but the time dedicated to FILL (2) must be chosen wisely. If FILL (2) occurs throughout FILL, then the substrate accumulated during FILL must be oxidized during REACT.

If REACT is not sufficiently long, poor treatment will result. The time in FILL (2), therefore, must be balanced against the total aeration time in FILL (3) and REACT in order to allow both mixed liquor settleability and BOD_5 and SS removal. At Culver these studies were carried out between May 1980 and May 1981. The average BOD_5, SS and SVI for both tanks and for

TABLE 3. Average Total Daily Time (Hours:Minute) North Tank in Each Period for Each Month Reported

	Month / No. of Observations	NORTH TANK (NT)						
		FILL (1)	FILL (2)	FILL (3)	REACT	SETTLE	DRAW	IDLE
1980	MAY 10	0:04	5:47	6:05	4:25	2:46	3:14	1:39
	JUN 15	0:07	4:56	7:16	1:39	2:54	3:20	3:48
	JUL 31	0:00	2:35	8:58	1:35	2:49	2:54	5:09
	AUG 27	0:04	2:08	9:12	2:13	2:55	2:38	4:50
	SEP 18	0:05	1:33	9:38	2:53	3:00	2:38	4:18
	OCT 30	0:00	3:08	8:38	2:51	2:36	2:35	4:12
	NOV 29	0:01	3:50	7:50	3:51	2:37	2:30	3:21
	DEC 28	0:02	4:55	7:21	3:03	2:50	2:42	3:07
1981	JAN 30	0:00	3:54	7:27	2:53	2:51	2:16	4:39
	FEB 24	0:01	4:27	7:00	2:48	3:14	2:37	3:53
	APR 14	0:06	1:28	9:30	1:23	3:56	2:45	4:53
	AVG 256	0:02	3:27	8:09	2:41	2:54	2:40	4:07
	AVG/ CYCLE	~0	0:52	2:02	0:40	0:44	0:40	1:02

TABLE 4. Average Total Daily Time (Hours:Minutes) South Tank in Each Period for Each Month Reported

	Month / No. of Observations	SOUTH TANK (ST)						
		FILL (1)	FILL (2)	FILL (3)	REACT	SETTLE	DRAW	IDLE
1980	MAY 10	0:00	6:11	5:53	3:32	2:51	3:17	2:16
	JUN 15	0:03	3:56	7:41	2:00	2:54	3:09	4:17
	JUL 31	0:00	4:25	8:03	1:48	2:52	2:58	3:52
	AUG 28	0:06	4:10	8:03	1:34	3:19	2:35	4:13
	SEP 18	0:00	3:56	8:53	1:04	3:00	2:52	4:15
	OCT 30	0:00	5:21	6:53	1:56	2:37	2:41	4:32
	NOV 29	0:00	6:10	6:10	2:06	2:36	2:58	3:58
	DEC 28	0:03	5:33	6:06	2:13	2:45	3:08	4:12
1981	JAN 30	0:00	5:17	7:22	1:37	2:52	2:34	4:18
	FEB 24	0:03	5:04	7:25	1:43	3:13	2:38	3:54
	APR 14	0:10	4:25	8:20	1:05	4:01	3:11	2:48
	AVG 257	0:02	4:59	7:19	1:29	2:57	2:52	4:21
	AVG/ CYCLE	~0	1:15	1:50	0:22	0:44	0:43	1:05

TABLE 5. Analysis of Average Total Daily Times

	North Tank	South Tank
Minimum Total Time in FILL, Hours:Minutes	11:04 (Apr '81)	11:40 (Jun '80)
Minimum % of FILL in FILL (2)	13% (Apr '81)	31% (Sep '80)
Minimum Aeration Time*/ % of Total Daily Time	8:55/37% (Jun '80)	8:16/34% (Oct '80)
Maximum Total Time in FILL, Hours:Minutes	12:19 (June '80)	12:32 (Apr '81)
Maximum % of FILL in FILL (2)	48% (May '80)	51% (May '80)
Maximum Aeration Time/ % Total Daily Time	12:55/52% (Apr '81)	9:57/41% (Sep '80)
Average Total Time in FILL, Hours:Minutes	11:39	12:21
Average % of FILL in FILL (2)	30%	40%
Average Aeration Time/ % of Total Daily Time	10:50/45%	8:48/37%

*FILL (3) plus REACT

this period is summarized below:

	Raw Wastewater	NT	ST
BOD_5, g/m^3	160 (152)*	9 (147)	10 (144)
SS, g/m^3	130 (263)	7 (258)	9 (258)
SVI, mℓ/g	-	140 (287)	120 (287)

*( ) = number of observations

Effluent BOD_5 measurements were conducted on pre-chlorination samples. Post chlorination BOD_5 effluent averaged 5 g/m^3 (143 observations).

Nitrification requires that the dissolved oxygen (DO) concentration be greater than approximately 0.5 g/m^3. FILL (2) clearly is in conflict with this need. As a result, the aeration time during FILL (3) and REACT must be sufficiently long and the DO must be sufficiently high to allow the enrichment of nitrifiers in the system during "start-up" and the completion of ammonium-nitrogen (NH_4-N) oxidation after "start-up". At Culver problems with the aeration equipment prevented the DO from climbing above 0.5 g/m^3 during virtually all of FILL (3) and sometimes part of REACT. While the BOD_5 and SS removals were not effected by the low DO's, nitrification was not possible until June 1981, when higher DO could be maintained. Average NH_4-N data (and SS and BOD_5 for comparison) for pre-and post-nitrification periods is summarized below:

	Raw Wastewater	NT	ST
May '80 to May '81:			
NH_4-N, g/m^3	19 (208)*	15 (206)	15 (206)
Aug. '81 to Dec. '81:			
NH_4-N, g/m^3	20 (82)	1.1 (79)	1.0 (78)
SS, g/m^3	150 (94)	5 (94)	6 (94)
BOD_5, g/m^3	170 (59)	11 (57)	10 (59)

Post-chlorination BOD_5 effluent (Aug. '81 to Dec. '81) = 7 g/m^3

*( ) = number of observations

Denitrification requires the DO to be less than approximately 0.5 g/m^3, the presence of nitrite and/or nitrate nitrogen (the sum of these two is reported as NO_x-N) and a carbon source for energy. Fill (2) provides the best conditions for denitrification until the oxidized nitrogen supply, left in the

residual liquid after DRAW, is exhausted. After all available NO_x-N is depleted, anaerobic reactions take place. FILL (3) is compatible with denitrification in that NO_x-N will be produced provided the DO is high enough but incompatible in the sense that the electron donor, in this case organic carbon, entering with the primary effluent is being oxidized aerobically with oxygen as a terminal electron acceptor; rather than anoxically with NO_x-N as the terminal electron acceptor. On the other hand the DO during FILL (3) and REACT must be high enough and maintained long enough to allow the oxidation of the entering ammonium-nitrogen, but low enough and of sufficient duration to allow denitrification.

All of the above process considerations for denitrification can be engineered into a new facility. At Culver, BOD_5 and SS removal and ammonium oxidation were considered quite likely even under the constraints of a retrofit. This was borne out by the data presented above for the period August 1981 to December 1981. Bench-scale studies suggested, however, that denitrification (except for the expected removal of the surprisingly high input of NO_x-N in the raw wastewater) would be difficult to achieve. As is shown below, these concerns were unfounded.

	Raw Wastewater		NT	ST
May '80 to May '81:				
NO_x-N, g/m^3	5.4	(210)*	1.7 (207)	1.4 (205)
NH_4-N plus NO_x-N, g/m^3	24		17	16
Aug. '81 to Dec. '81:				
NO_x-N, g/m^3	2.0	(80)	1.3 (81)	1.3 (81)
NH_4-N plus NO_x-N, g/m^3	22		2.4	2.3

*( ) = number of observations

The ammonium plus oxidized nitrogen data are sums of averages and represent an estimate of the input nitrogen that was available for denitrification. The actual amount could be either more or less depending upon the amount of organic nitrogen that was processed into ammonium-nitrogen or cell mass. From random samples collected, the concentration of organic nitrogen in the raw wastewater was found to be between 10 and 15 g/m^3 and between 1 and 3 g/m^3 in the effluent (as N).

While BOD_5, SS, ammonium and oxidized nitrogen were achieved biologically, phosphorus removal at Culver was accomplished by adding ferric chloride (until October 24, 1981) or alum (after October 24, 1981). Biological phosphorus removal was not attempted at Culver. This is not meant to suggest that biological phosphorus removal is not possible in an SBR. The scope of activities at Culver simply did not allow investigation of this

interesting phenomenon. In fact, phosphorus removal was not considered a part of the project, only a treatment requirement for the Town of Culver, which must be continued during SBR operation, to meet state discharge requirements.

Chemical phosphorus removal was achieved rather simply. Either a ferric chloride or alum solution were added continuously at a constant rate (9 kg/d ferrous ion or 42 liters/d of 8.1% Al_2O_3) to the primary effluent. The results of this effort are summarized below for the two descrete periods discussed previously.

	Phosphorus, g/m^3-P		
	Raw Wastewater	NT	ST
May '80 to May '81	6.3 (221)*	0.4 (218)	0.5 (217)
Aug. '81 to Dec. '81	6.5 (84)	0.7 (85)	0.8 (85)

*( ) = number of observations

The slightly greater effluent concentrations listed for August 1981 to December 1981 were generally higher during each month of this period independent of the chemical used for precipitation.

SECTION 6

SBR CONVERSION

As in any retrofit design, the modifications incorporated at Culver were strongly influenced by the existing physical plant. In addition, the absence of any full-scale SBR to serve as an example resulted in the installation of equipment that had to be either modified or replaced during the course of the study, fortunately without loss of SBR performance.

The experiences gained at Culver will be of value to other retrofit designs and new SBR construction. The specific equipment and techniques used at Culver, however, are important for only two reasons. First, a general understanding of the system installed is necessary for the proper interpretation of this report. Second, a review of operating difficulties encountered will assist in defining equipment requirements for future SBR facilities. As a result, this section will emphasize the various systems tested and problems encountered rather than providing detailed design information. A summary of manufacturers and suppliers for major equipment and materials used is presented in Table 6.

As was noted earlier, the two existing aeration tanks were the major components in the conversion. Each tank was operated at a maximum liquid depth of approximately 3.4 m and considering the Y-wall construction, was roughly 23 m long and 7 m wide. Major emphasis was placed on the following four areas:

TABLE 6. Summary of Equipment and Materials Used

Item	Use	Manufacturer/Supplier
Pinch Valves	Inlet Control	Red Valve Company
Stop Gates	Inlet Control	Sybron/Leopold, Inc.
Treated Lumber	Baffle Walls	Chicago Flame, Inc.
Misc. Structural Steel	Baffle Walls	Fabricated Steel Products
Float Switches	Level Control	Hydromatic Inc.
Aeration Blowers	Air Supply	Sunstrand Fluid Handling Inc.
Submersible Pumps	Mixing/Oxygen Transfer	Hydromatic Inc.
Fiberglass Pipe & Fittings	Air/Liquid Piping	Fibercast, Co.
Jet Aeration Nozzles	Oxygen Transfer	Pentech, Corp.
Submersible Pumps	Decant Pumping	Flygt Corp.
Pinch Valve	Decant Bypass	Red Valve Company
Jet Chlorination Unit	Disinfection	Pentech, Corp.
3 Way Solenoid Valve	Pneumatic Controls	Humphrey, Co.
Air Compressor	Pneumatic Controls	Ingersold Rand, Corp.
Microprocessor	Control	Xycom Inc.
5 TI Controller	Sequencing of Unit Operations Automatically	Texas Instruments, Inc.

- The Inlet and Inlet Chamber
- The Outlet
- The Aeration System
- The Control System

Each of the above areas is discussed briefly in the pages which follow. A general schematic of the aeration tanks showing modifications is provided in Figure 3 for convenience.

The inlet and inlet chamber. An 8 inch (20 cm) pinch valve mounted to a stop gate replaced the inlet gate for each tank. Other inlet devices considered included an automatic sliding gate, motorized valves and pumps. The pinch valves operated without difficulty throughout the study period. Their operation was rather simple: a rubber bladder was inflated by a small air compressor (0.4 kW) at the end of FILL and air pressure released at the beginning of FILL. Two 3-way solenoid valves, controlled by a microprocessor, regulated air flow to one bladder or the other. A float switch signalled the microprocessor when the maximum liquid level was reached. Although the pinch valves worked quite well, the diameter selected limited flow through each valve to approximately 3000 m^3/d, and created unexpected problems during the late spring and summer of 1981, when record high flows reached the Culver plant.

The inlet chamber (see Figure 3) was formed by constructing a baffle wall of wooden planks perpendicular to the side walls some 2 m from the inlet. An open space of approximately 20 cm along the entire bottom of the wall allowed transfer of primary effluent to the main portion of the aeration tank. The inlet chambers minimized any short circuiting that might occur during FILL (1) operation. No definitive process information was determined for the inlet chamber. During operation a jet aerator (1.6 kW) placed in the inlet chamber may or may not be in operation depending upon operator preferences.

The Outlet. A float mounted submersible pump (7 kW) direct coupled to suction draw-off pipe was installed in each tank (see South Tank, Figure 3). The draw-off pipe, parallel to the end wall, withdrew treated effluent approximately 36 cm below the water surface throughout DRAW. The beginning of DRAW was signalled (by the microprocessor) approximately 45 minutes after the beginning of SETTLE and continued for 40 to 45 minutes (see Tables 3 and 4 and APPENDIX I for more detail on these times). The end of DRAW was determined by a float switch located approximately 1.4 m from the maximum water level. The microprocessor was also programmed to shut-off the pump after a predetermined time (e.g. 50 minutes) in case the level switch malfunctioned. As a final precaution against the pump dipping into the sludge blanket and discharging mixed liquor to the stream, a support table about 1.2 m high was anchored to the bottom beneath the decant device. The table served as a physical obstruction preventing further downward travel of the pump. The discharge from the pump passed through a jet disinfection unit (described below) before entering one of the two secondary clarifiers.

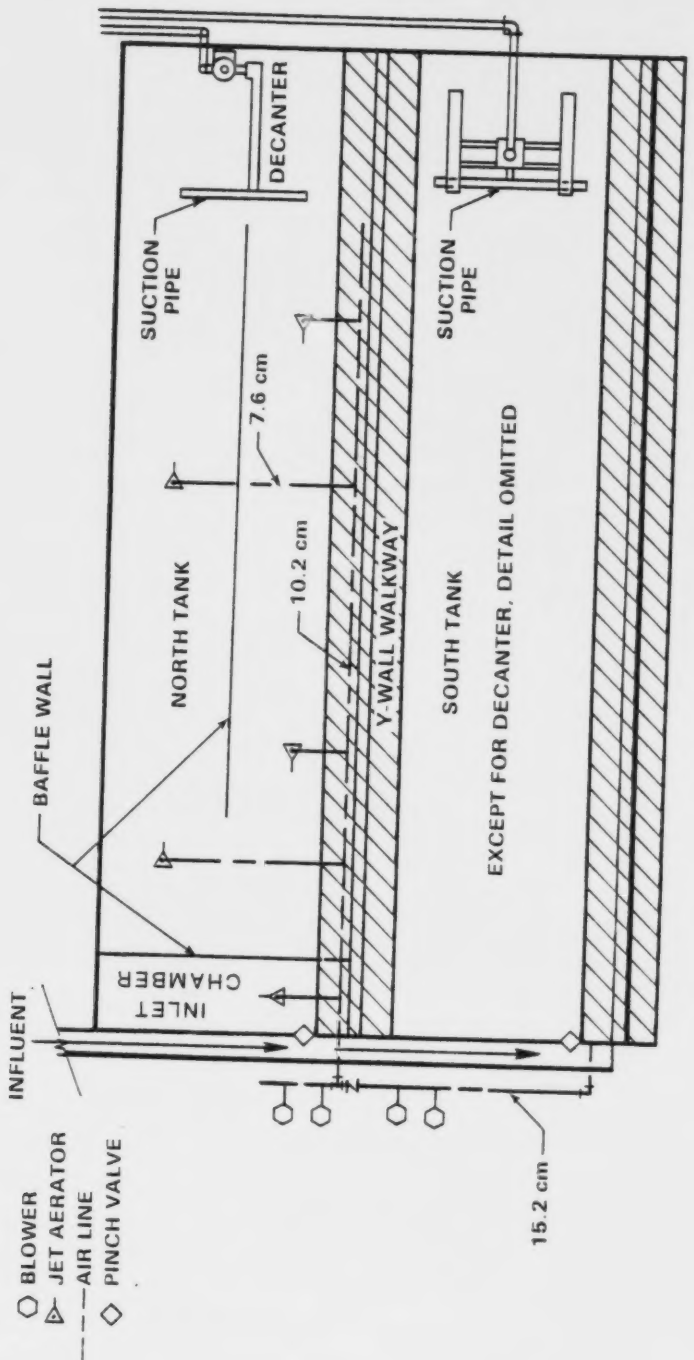

FIGURE 3. Modification of Aeration Tanks at Culver

The decant device as installed served the general purpose of allowing SBR operation but had several basic design and operational problems:

- Decant took place too far below the water surface leaving behind a considerable volume of the treated effluent. A small modification brought the suction draw-off pipe closer to the surface but did not materially improve the situation.

- Pump maintenance was difficult. Although no pump maintenance problems were experienced during the course of the study, the decant device was bulky and not easily reached and serviced. As a result, the system in the North Tank was changed in August 1980 by mounting the submersible pump on the end wall such that it could be easily lifted out for servicing (see North Tank, Figure 3). The suction draw-off pipe was connected to the pump through a swivel joint and floated below the surface by an air-filled, sealed ballast pipe.

- Because the suction pipe remained in the mixed liquor with open suction ports exposed during FILL, REACT and SETTLE, a small volume of mixed liquor accumulated in the pipe and around the support apparatus and was discharged, ultimately to the stream. After approximately 30 to 60 seconds into DRAW, the suction pipe and supports were clear of mixed liquor solids. Throughout the SBR study period, the average effluent SS from NT and ST after the initial flush of solids were 7 and 8 g/m^3 respectively. The average leaving the accumulated flow in the secondary clarifiers was 14 g/m^3. This difference between the SBR tanks and the final effluent amounts to only 1 kg of solids per flush. The decant device was modified at the end of the study period to return the first flush to the inlet chamber, thus solving this problem.

- Chlorination was accomplished using a jet disinfection unit. This unit is a coffin like box which aspirates chlorine through a jet pump located in the box whenever effluent from either tank is pumped through the box. The unit cannot quite handle the maximum potential flow rate from one decant pump (approximately 65 ℓ/s). As a result, system flexibility was somewhat limited. For example, only one SBR tank could be discharged at a time and whenever the instantaneous flow rate to one tank increased severely, the time needed to discharge the other tank could not be shortened due to this discharge restriction.

In spite of the above difficulties the decant systems did perform quite satisfactorily throughout the study period even with the prototype construction.

The Aeration System. In order to satisfy both FILL (2) and FILL (3) requirements, the University of Notre Dame accepted a donation of jet aeration equipment from the Pentech Division of Houdaille Industries, Inc. Five jet aerators were installed in each tank as is shown in Figure 3. Air lines fed each pump. Two high speed 7.5 kW aeration blowers were dedicated to NT and two to ST. A center baffle wall was installed (using the same

materials as for the inlet chamber wall) to improve oxygen transfer. The existing coarse bubble diffuser drop pipes were removed and the two original 45 kW blowers were left hooked-up to the air lines feeding NT only for possible use in special studies. When the pumps were activated, the flow in the tank moved in a circular direction around the center baffle wall.

Operation was generally rather simple. For FILL (2), the pumping action of the jets was activated when the pinch valve was opened if the tank were in IDLE and after reaching the minimum liquid level, if the tank were in FILL (1). When a float switch at approximately the 2.6 m level (from bottom) was tripped, the microprocessor activated the blowers to achieve FILL (3). After the pinch valve closed, the blowers and jet aerators then remained on until one of two conditions was satisfied: either the maximum allowable time in REACT was reached or the liquid level in the other tank tripped a switch, located at approximately the 2.5 m level, thus "informing" the microprocessor that SETTLE and DRAW must be initiated or the tank will not be ready for its turn at FILL.

Major problems were encountered with these high speed aeration blowers. Each installed blower failed and each replacement or modified unit either failed or developed the same mechanical whine that had preceded failure of the earlier units. Because of the difficulties, only one blower was used at a time and then usually at 70% of capacity. As a result, the high DO's needed for nitrification were not possible. The manufacturer finally resolved the difficulties but it wasn't until May 1981 that two blowers were operated in parallel so that the population of nitrifiers could be established.

Other than the difficulties with the blowers, the jet aeration system operated satisfactorily.

The Control System. The Electrical Engineering Department at the University of Notre Dame developed, built and installed a microprocessor control system for the Culver facility. Unfortunately the control system developed many problems that could not be easily remedied by the treatment plant operator. The system finally failed completely in May 1981 and was replaced by a commercial unit which was installed in August 1981. The new system is quite easy to operate and adjust. Few additional problems are expected.

The microprocessor control system operated with either level or time data. Level data were supplied by the float switches. Time was maintained by the microprocessor's internal clock. An example of one of the several control strategies implemented at Culver is summarized in Table 7.

The cost of the equipment and supplies used for the first round of modifications is summarized in Table 8. Of the $75,600 listed, $42,000 was used to replace totally the aeration equipment. In addition, the new commercial process controller system cost only $4000 (vs. the $12,000 for the unit fabricated at Notre Dame).

TABLE 7. Control of SBR as Viewed From North Tank Switches

Float Switch Level NT (meters above bottom)	Function	Override Time Control For Function Listed
2.0 (ST in FILL)	· End DRAW NT · Begin IDLE NT	· Maximum Time in DRAW = 50 minutes
2.0 (NT in FILL (1))	· End FILL (1) NT · Begin FILL (2) NT	· None
2.5	· End REACT ST · Begin SETTLE ST	· Maximum Time in REACT = 90 minutes · Time ST in SETTLE = 45 minutes
2.6	· End FILL (2) NT · Begin FILL (3) NT	· None
3.4 (ST in IDLE)	· End FILL (3) NT · Begin REACT NT · End IDLE ST · Begin FILL (2) NT	· None
3.4 (ST in DRAW)	· End FILL (3) NT · Begin REACT NT · End DRAW ST · Begin FILL (1) ST	· None

TABLE 8. Summary of Modifications and Approximate Costs for Culver, Indiana, Retrofit, 1340 m^3/d

Item	Description	Approx. Cost
Pinch Valves (2)	Regulate Inlet Flow	$3,500
Stilling Chamber Lumber	Allow FILL (1)	1,300
Center Wall Lumber	Improve Oxygen Transfer	3,000
Compressors	Four at 7.5 kW each	6,000
Directional Jets	Five per Tank at 1.6 kW each	23,500
Air Lines and Valves	Air Supply to Jets	9,500
Decant System (2)	Floating Submersible Pump	15,000
Decanter Platforms (2)	Limit Decanter Discharge	500
Level Detectors (8)	Monitor Liquid Level	3,300
Motor Control Center (1)	Control Installed Equipment	6,000
Microprocessor	Control System	4,000
	Total	$75,600

SECTION 7

ADDITIONAL PERFORMANCE DATA

Data presented in earlier sections demonstrate that BOD_5, SS and phosphorus removal, nitrification and denitrification were, on the average, reasonably good. The purpose of this section is to summarize monthly and daily performance data. All averages reported are weighted on a daily rather than a monthly basis.

All data were obtained from daily grab samples collected on the raw wastewater (RWW), primary effluent (PE), north tank effluent (NT), south tank effluent (ST) and final effluent (FE). Tables 9, 10 and 11 provide rounded monthly average data for the SBR operating period (May 14, 1980 to May 23, 1981 and August 19, 1981 to December 31, 1981). Daily information is presented for all days (including May 24, 1981 to August 18, 1981) in APPENDIX II. A pictorial description for monthly average effluent data for BOD_5, SS, phosphorus and NH_4-N is given in Figures 4, 5, 6 and 7 respectively. Histograms depicting scatter of daily effluent data is presented for the same parameters in Figures 8, 9, 10 and 11. As can be seen from these data effluent quality was both satisfactory and reasonably stable.

Because of both aberrant high rainfall and raw wastewater flow rates (see Table 12) and the final breakdown of the University fabricated microprocessor, the Culver facility operated in a modified continuous flow mode between May 24, 1981 and August 18, 1981, with the final clarifiers in usual operation with recycle pumps. Each morning between approximately 6:30 AM and 10:00 AM the jet aeration mixing pumps and blowers were shut off so that sludge accumulated in the secondary clarifiers could be pumped-down and returned to the reactor. During this time, the clarified supernatant in the aeration tanks was "pushed" into and through the clarifiers by the primary effluent. By 10:00 AM power to the aerators was restored and the system was operated as a conventional continuous flow facility (i.e., in the same manner used prior to SBR conversion). This modified continuous flow mode has some characteristics of many of the periodic systems operated in Denmark.

During modified continuous flow operation, both aeration tanks were used in parallel in May and June. Only the South Tank was used in July and only the North Tank in August. Plant performance during this period was also quite good as can be seen from the data presented in Table 12. More detailed daily information for this period may be found in APPENDIX II. As can be seen from the data, nitrification and denitrification began in June 1981.

SECTION 8

BASIC DESIGN CONSIDERATIONS

Loading Terms. At Culver, sludge was wasted daily from each SBR tank during IDLE. The sludge age (mass of sludge in the reactors divided by the mass of sludge wasted each day) generally ranged between 15 and 45 days. While the

TABLE 9. Average Monthly Data (Rounded) for 5-Day BOD and Suspended Solids for SBR Operating Period

DATE		BOD_5, g/m^3					SUSPENDED SOLIDS, g/m^3				
		RWW	PE	NT	ST	FE	RWW	PE	NT	ST	FE
1980	MAY	160	120	6	9	2	120	80	7	10	11
	JUN	140	100	6	6	3	120	80	5	4	9
	JUL	180	120	11	8	4	140	80	7	6	8
	AUG	130	100	10	14	11	100	70	5	9	12
	SEP	140	120	11	14	5	120	90	8	7	14
	OCT	170	130	10	9	4	170	80	10	9	12
	NOV	180	150	9	8	3	150	70	6	8	13
	DEC	160	110	10	11	6	120	70	7	9	14
1981	JAN	160	130	9	10	3	120	80	10	10	15
	FEB	160	150	13	16	7	120	70	9	13	24
	MAR	170	130	8	9	5	140	80	7	9	17
	APR	170	100	8	9	12	160	70	8	15	23
	MAY	130	90	8	8	7	110	70	6	9	17
	AUG	110	90	5	7	4	120	70	3	5	9
	SEP	170	100	6	5	3	170	70	3	3	7
	OCT	160	110	11	10	4	160	80	4	6	12
	NOV	170	130	14	10	8	170	100	10	6	9
	DEC	180	120	12	13	11	130	90	6	8	12
	AVG	160	120	10	10	4	140	80	7	8	14
	DATA PTS	211	210	204	203	202	357	356	352	252	251

RWW = Raw Wastewater
PE = Primary Effluent
NT = North Tank
ST = South Tank
FE = Final Effluent

TABLE 10. Average Monthly Data (Rounded) for Nutrients for SBR Operating Period

	DATE	NH_4-N, g/m^3 as N					NO_x-N, g/m^3 as N					PHOSPHORUS, g/m^3				
		RWW	PE	NT	ST	FE	RWW	PE	NT	ST	FE	RWW	PE	NT	ST	FE
1980	MAY	22	20	19	18	19	7	7	0.6	0.7	1.4	6	6	1.0	1.1	0.9
	JUN	16	15	15	14	15	6	5	0.8	1.4	1.2	5	5	0.4	0.4	0.6
	JUL	23	21	18	17	19	8	7	7	5	5	7	7	0.3	0.3	0.6
	AUG	18	16	17	10	9	8	7	7	5	5	6	7	0.3	0.4	0.7
	SEP	20	19	5	8	6	8	7	6	4	5	6	6	0.5	0.3	0.7
	OCT	23	22	15	19	18	8	8	2.5	0.8	1.5	9	8	0.4	0.6	1
	NOV	21	23	20	21	21	8	7	0.7	1.0	1.4	8	7	0.3	0.4	0.7
	DEC	19	19	17	17	18	4	3	0.5	0.5	0.7	7	6	0.6	0.6	0.9
1981	JAN	22	21	19	19	20	5	5	0.6	0.5	0.7	6	5	0.5	0.4	0.7
	FEB	17	17	16	16	17	2.5	2.5	0.4	0.6	0.5	5	4	0.5	0.6	0.9
	MAR	20	19	19	18	18	2.8	2.6	0.4	0.4	0.4	6	5	0.4	0.4	0.7
	APR	17	17	17	16	16	2.4	2.3	0.4	0.5	0.3	5	4	0.6	0.6	0.8
	MAY	17	16	13	13	13	1.4	1.6	0.4	0.4	0.4	5	5	0.9	0.9	1.1
	AUG	16	13	0.3	0.8	0.6	1.9	1.8	1.7	1.2	1.6	5	4	0.9	0.9	0.9
	SEP	20	17	0.8	0.7	1.0	1.9	2.2	1.6	1.6	1.7	7	6	0.8	1.0	1.0
	OCT	19	19	1.4	0.6	1.8	2.2	2.2	1.0	1.1	1.0	6	5	0.6	0.7	0.8
	NOV	23	20	1.7	0.7	1.0	2.6	1.8	1.2	1.4	1.2	7	5	0.7	0.7	0.7
	DEC	20	18	0.9	1.9	1.3	1.6	1.8	1.2	1.4	1.4	8	6	0.6	0.9	0.8
	AVG	19	18	11	11	12	5	4	1.6	1.4	1.5	6	6	0.5	0.6	0.8
	DATA PTS	290	288	285	284	289	290	289	287	286	286	305	303	303	302	305

RWW = Raw Wastewater
PE = Primary Effluent
NT = North Tank
ST = South Tank
FE = Final Effluent

TABLE 11. Average Monthly Data for Reactor Solids, Sludge Volume Index, Flow and Precipitation for SBR Operating Period

DATE		MLSS, g/m^3		SVI, mℓ/g		FLOW, m^3/d	PPT, mm
		NT	ST	NT	ST		
1980	MAY	1700	1700	150	140	1240	86
	JUN	2300	1900	130	130	1250	113
	JUL	2500	1900	110	100	1240	60
	AUG	2800	2300	120	100	1350	208
	SEP	2800	2400	120	130	1340	103
	OCT	2600	2100	180	150	1230	79
	NOV	2400	2100	200	140	1170	50
	DEC	2400	2400	150	140	1300	102
1981	JAN	2100	2300	130	110	1320	8
	FEB	2400	2300	140	100	1470	66
	MAR	2400	2000	130	100	1260	38
	APR	2200	2000	190	120	1600	212
	MAY	2700	2400	140	110	1980	215
	AUG	2700	2300	110	140	1570	66
	SEP	2800	2300	190	130	1330	108
	OCT	2700	3000	190	130	1430	71
	NOV	2800	2400	140	110	1250	128
	DEC	3100	2400	130	90	1160	51
	AVG	2500	2200	150	120	1340	-
	DATA PTS	403	400	392	392	508	-

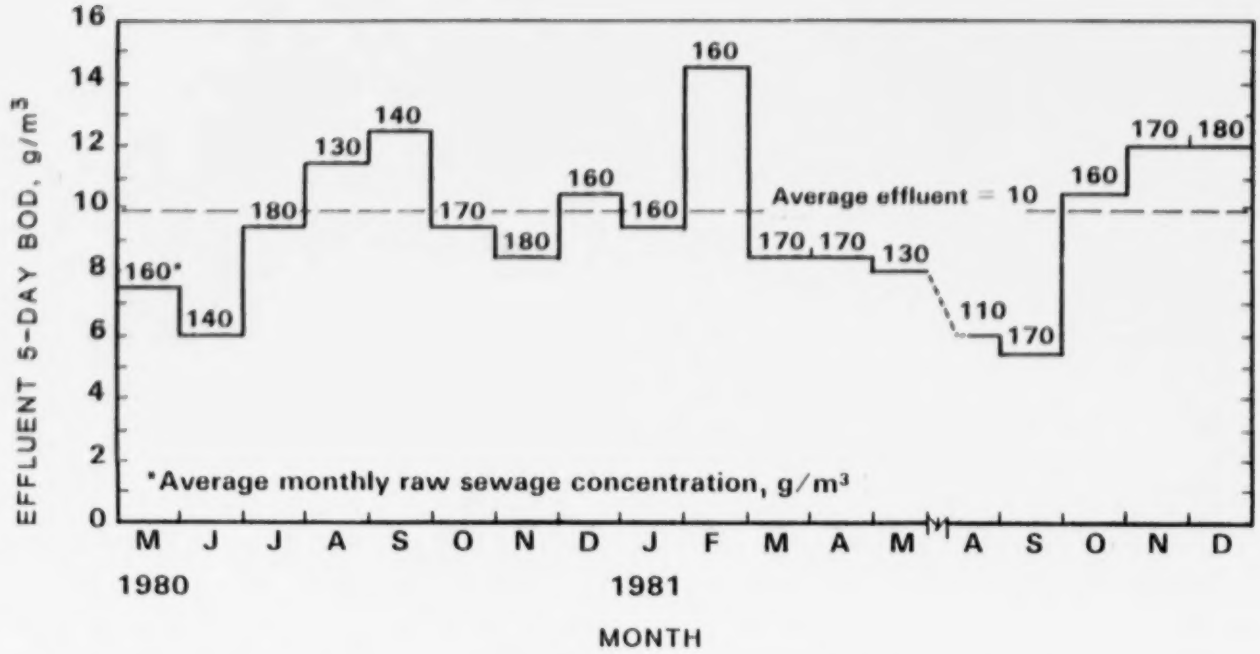

FIGURE 4. Monthly Average Effluent 5-Day BOD Concentrations for Both Tanks Combined During SBR Operating Period

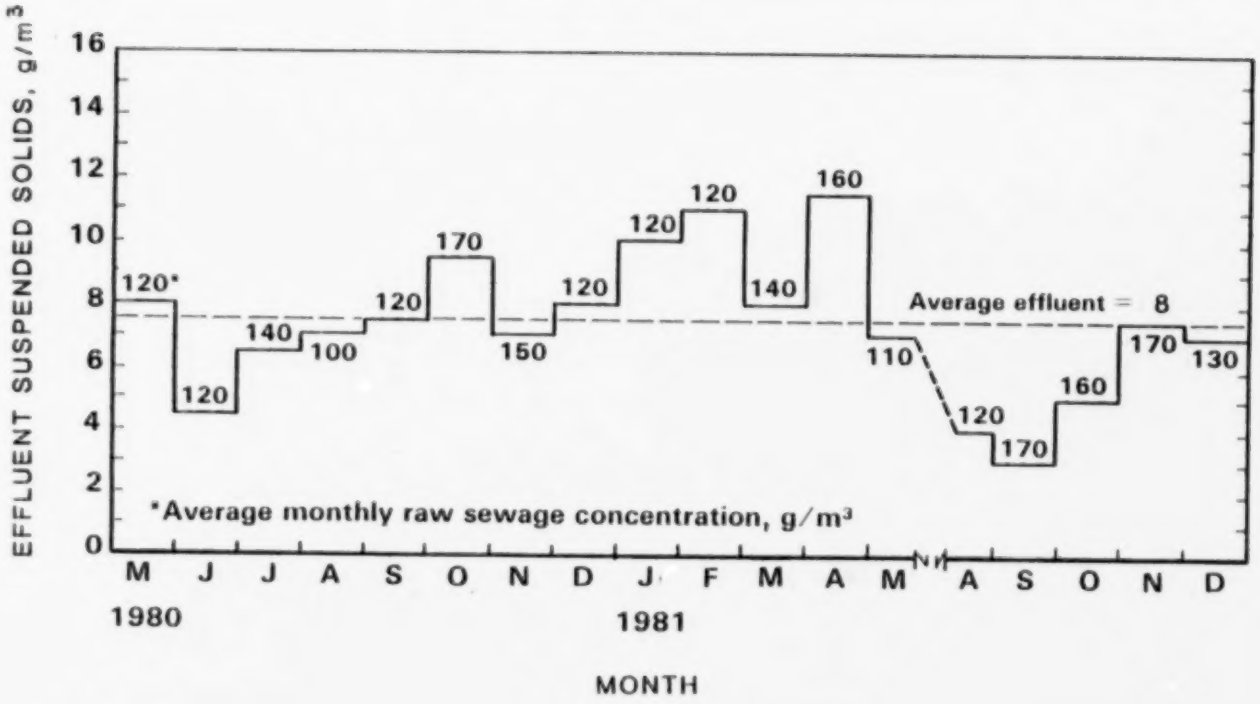

FIGURE 5. Monthly Average Effluent Suspended Solids Concentrations for Both Tanks Combined During SBR Operating Period

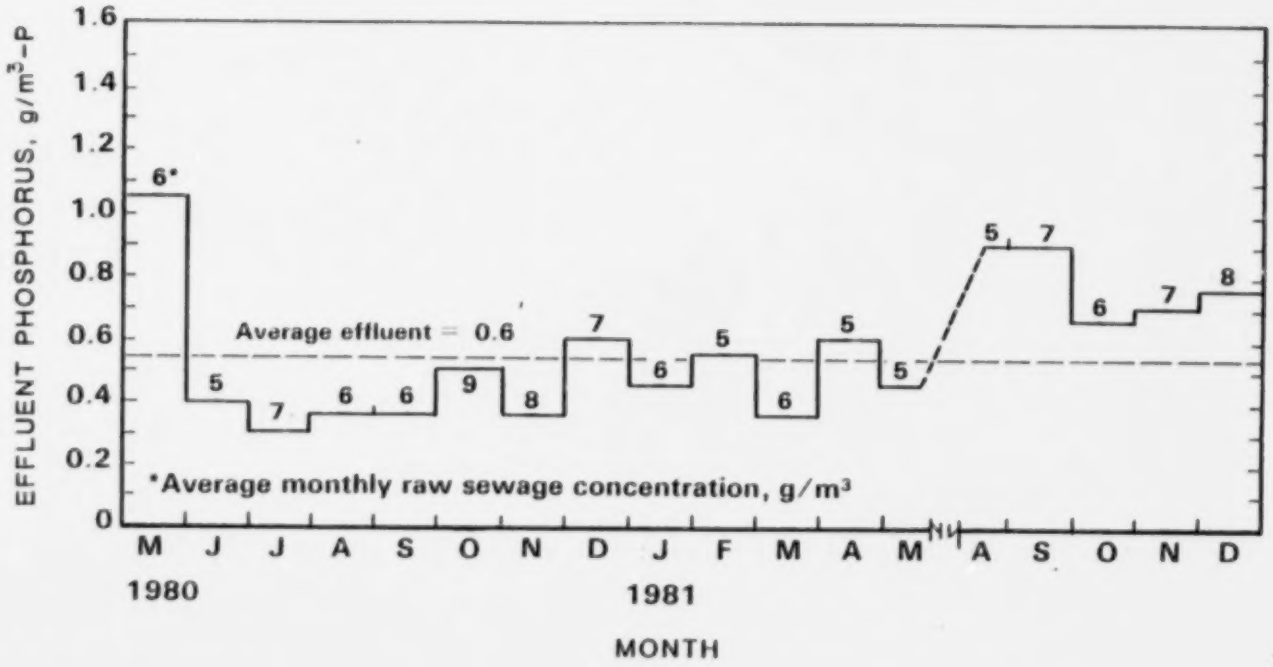

FIGURE 6. Monthly Average Effluent Phosphorus (as P) Concentrations for Both Tanks Combined During SBR Operating Period

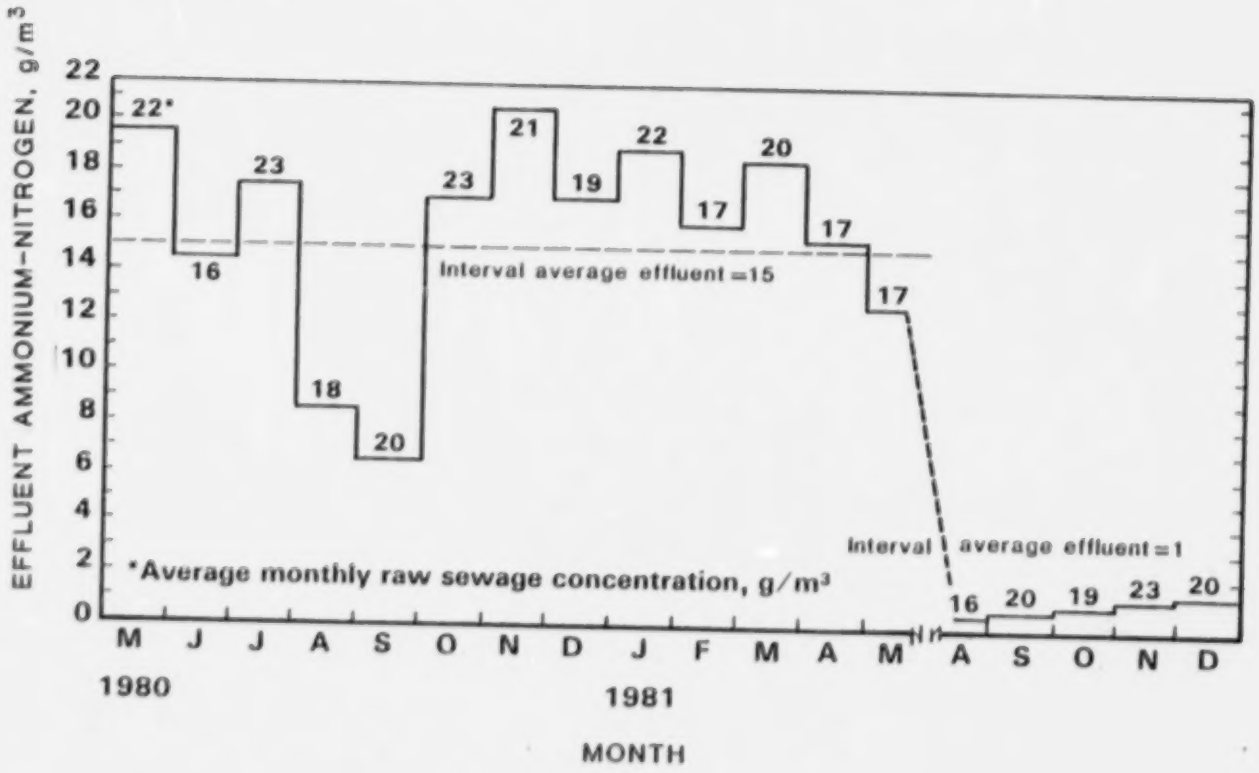

FIGURE 7. Monthly Average Effluent Ammonium-Nitrogen Concentrations for Both Tanks Combined During SBR Operating Period

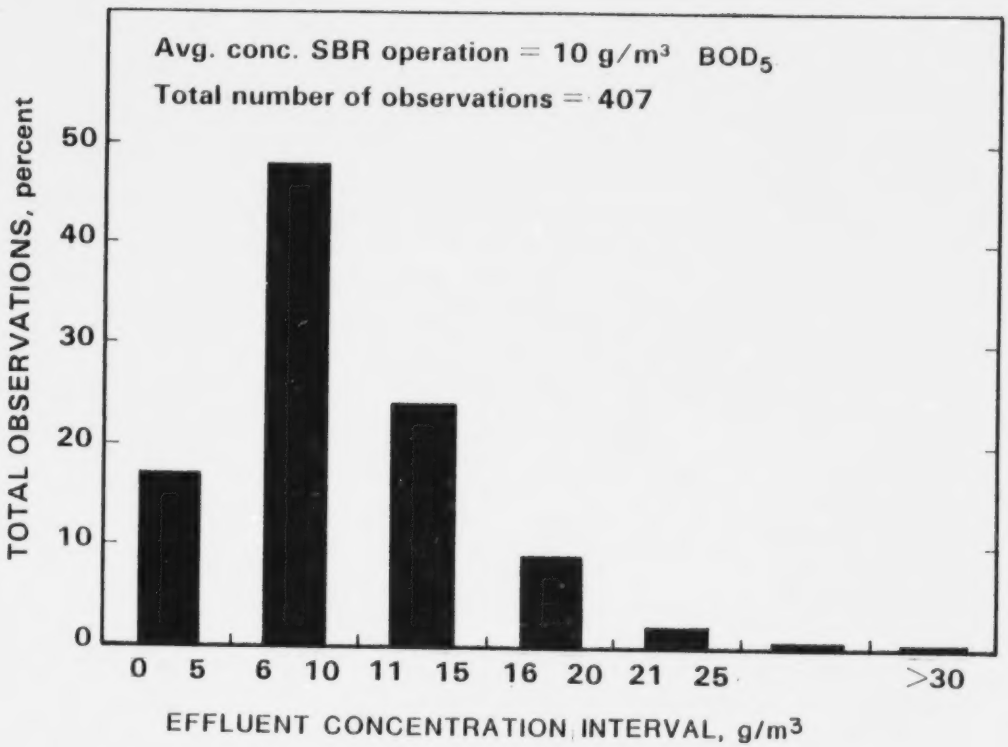

FIGURE 8. Percent of Effluent 5-Day BOD Observations from Both Tanks Which Fall in the Concentration Interval Shown (5/14/80 to 5/23/81 and 8/19/81 to 12/31/81)

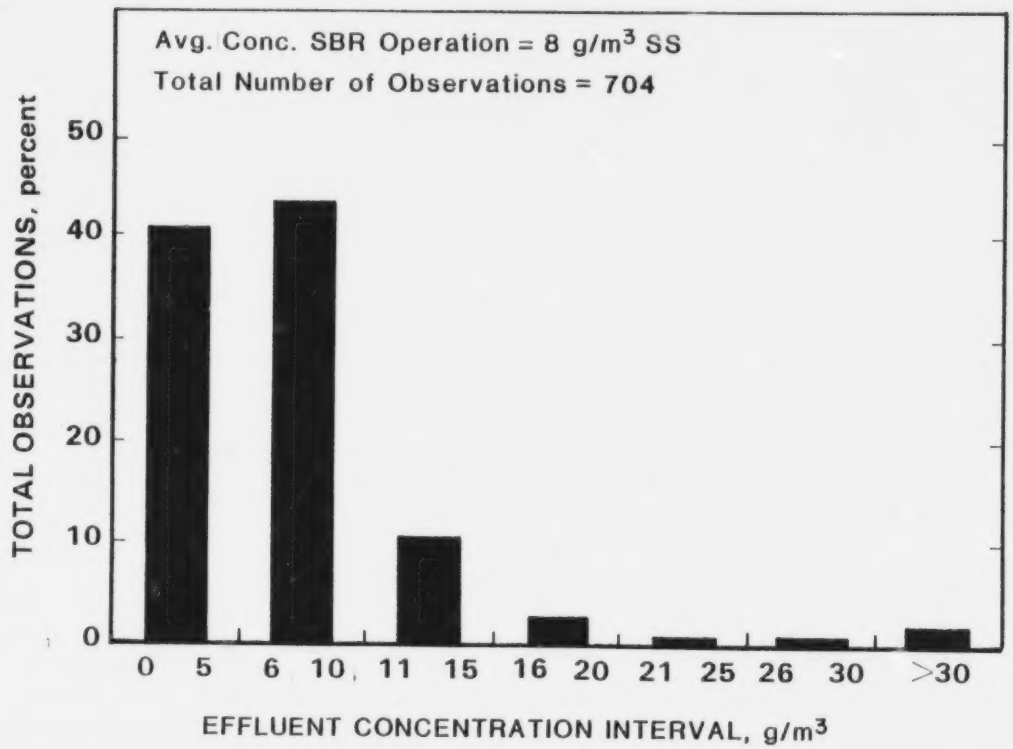

FIGURE 9. Percent of Effluent Suspended Solids Observations From Both Tanks Which Fall in the Concentration Interval Shown (5/14/80 to 5/23/81 and 8/19/81 to 12/31/81)

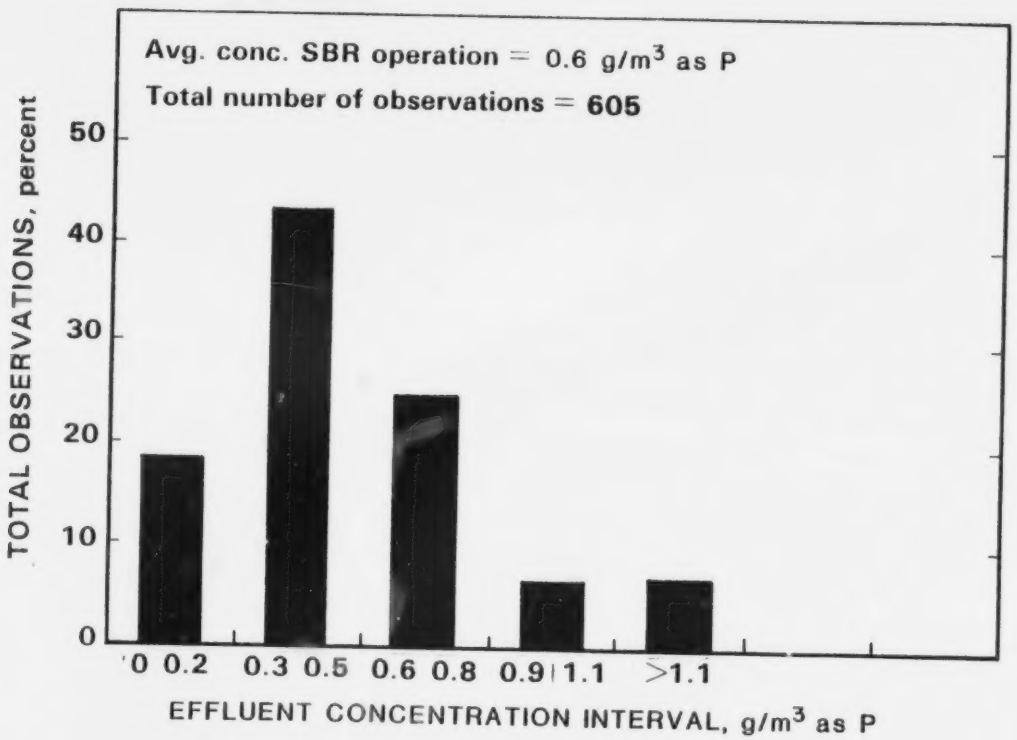

FIGURE 10. Percent of Effluent Phosphorus Observations From Both Tanks Which Fall in the Concentration Interval Shown (5/14/80 to 5/23/81 and 8/19/81 to 12/31/81)

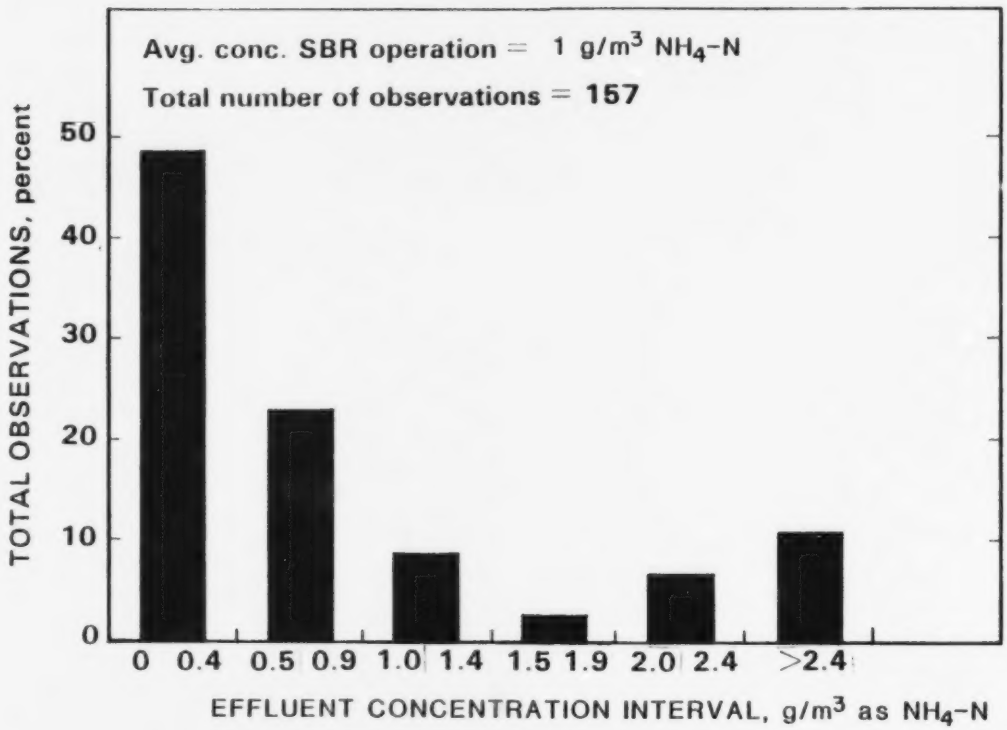

FIGURE 11. Percent of Effluent Ammonium-Nitrogen Observations From Both Tanks Which Fall in the Concentration Interval Shown (8/19/81 to 12/31/81)

TABLE 12. Monthly Average Data (Rounded) for the Modified Continuous Flow Operating Period (May 24, to Aug. 18, 1981)

	PPT	FLOW	BOD_5, g/m^3			SS, g/m^3			NH_4-N, g/m^3			NO_x-N, g/m^3
	mm	m^3/d	RWW	PE	FE*	RWW	PE	FE	RWW	PE	FE	FE
MAY	44	1740	110	40	14	90	40	9	15	14	12	1.0
JUN	432	2370	110	70	9	130	50	9	9	9	4	1.1
JUL	131	2030	130	70	6	160	60	6	15	12	0.8	2.1
AUG	17	1510	130	80	5	140	70	7	18	15	1.0	1.8
AVG	-	2010	120	70	8	140	60	8	13	11	3	1.6**
NO.†	-	88	28	28	28	57	57	57	37	37	37	34

*Post-chlorination

**Average Raw Wastewater NO_x-N concentration was also 1.6 g/m^3

†Total number of observations for all months

RWW = Raw Wastewater PE = Primary Effluent FE = Final Effluent

sludge age was in the range necessary to expect nitrification, the absence of sufficiently high DO's prevented nitrification during the first SBR operating period (May 1980 to May 1981) without hampering BOD_5 and SS removal.

In the SBR, the volume occupied by the sludge after settling will control the maximum MLSS concentration possible. For example, 1150 kg of solids (i.e., the mass corresponding to 2500 g/m^3 MLSS in the 460 m^3 tank at the end of REACT) would occupy, after sedimentation, 115 m^3 for an "in tank" SVI of 100 mℓ/g and 1.5 m for 200 mℓ/g. At Culver, the top 1.4 m was usually removed from the tanks (out of a total depth of 3.4 m). As a result, the maximum MLSS possible was between 2500 g/m^3 and 3000 g/m^3 for the SVI's reported at Culver. This, of course, placed a limit on the maximum possible sludge age.

Because of the periodic nature of the SBR, and the ability to vary the relative time in FILL (2) and FILL (3) as well as the extent of REACT, the value of sludge age as a useful control parameter can not be established at this time.

Two other parameters, loading (mass of BOD_5 applied per day per mass of sludge under aeration) and detention time, also must be used advisedly in SBR design and operation. For example, during the full SBR operating period the average flow and primary effluent BOD_5 were 1340 m^3/d and 120 g/m^3 respectively. The two tank average MLSS concentration was 2350 g/m^3 (see Table 11) and the percent volatile solids based on 168 measurement conducted from April through September 1981 was roughly 60%. Thus the kg BOD_5 applied per day per kg mixed liquor volatile suspended solids (MLVSS) averaged approximately 0.12. Considering that the organisms were under aeration for only 41% of the time (average, both tanks, see Table 5), an argument can be made that the actual loading was 0.30 kg BOD_5/kg MLVSS-d. On this basis, the loading ranged from a low of 0.2 in December, 1981 to a high 0.4 in February 1981. As with sludge age, little or no consideration was given to loading as far as plant operation was concerned. Alternatively, organics accumulated during FILL (2) must be allowed to be oxidized during FILL (3) and REACT. The higher the loading the shorter FILL (2) must be. The system at Culver was not stressed with respect to loading. As a result, the organic removal limitation for the SBR was not determined.

Hydraulic Detention Time. As with sludge age and loading, a definition for detention time for the SBR is not immediately obvious. At Culver the average daily flow rate was 1340 m^3/d. The maximum total SBR liquid volume was 920 m^3. Thus an average detention time of 0.7 days can be calculated. Noting that either tank was at its maximum liquid level less than 25% of the time, this detention time represents an upper limit. A lower limit can be determined from the minimum total liquid volume of 460 m^3 or 0.35 days. The "true" detention time clearly lies between these two extremes. In actuality a tank that serves as an equalization basin, reactor and clarifier cannot be associated easily with such a simple parameter as detention time.

A much more useful analysis comes from considering the hydraulic limitations at Culver. In particular, the maximum raw wastewater flow rate that would

pass through either pinch valve was 3000 m^3/d. The discharge, because of the disinfection unit, was limited to 5600 m^3/d. Ignoring these limitations for the moment, the theoretical maximum daily flow rate that can be handled at Culver can be estimated by noting that the time required for REACT, SETTLE and DRAW is approximately two hours (see Tables 3 and 4) allocating 0.7 hours each for SETTLE and DRAW and 0.6 hours for REACT. By eliminating IDLE, and not allowing FILL (1), the total time in FILL must be two hours also. With a maximum fill volume of 230 m^3, the maximum daily constant flow rate that could be handled is roughly 115 m^3/hr or 2760 m^3/d (0.73 mgd). During June 1981, twelve days had average daily flow rates equal to or above 2760 m^3/d and several more days had maximum hourly flow rates that exceeded that limit.

Obviously an average daily flow rate of 2760 m^3/d would not be possible without either eliminating part (or all) of REACT or allowing FILL (1) for those cycles receiving instantaneous hourly flow rates greater than 2760 m^3/d. For example, an instantaneous flow rate of 3940 m^3/d could be handled during one cycle by eliminating REACT. Unfortunately the maximum flow rate that can be accepted at Culver is 3000 m^3/d.

The discharge flow rate limitation also caused difficulties. Emergency withdrawals could not exceed 5600 m^3/d. As a result, a tank half-way through DRAW (after 0.35 hours, 115 m^3 remaining to be discharged) would require 1.06 hours in FILL (1) before the minimum liquid level was reached in a system using two hours for REACT, SETTLE and DRAW and receiving primary effluent at a rate of 3000 m^3/d. A 7600 m^3/d discharge flow rate would reduce the FILL (1) time to 0.6 hours.

Examples of this type could be endless but the design engineer should consider all reasonable possibilities. At Culver, the worst case condition encountered prior to SBR conversion was a flow of 2650 m^3/d for twelve consecutive hours. After conversion a rainfall of 8.35" (212 mm) in April 1981 followed by two record months of 10.2" (259 mm) in May, 1981 and 17" (432 mm) in June 1981 resulted in daily average flow rates greater than 2650 m^3/d and instantaneous hourly peaks of nearly 4000 m^3/d.

For the inlet and outlet limitations at Culver the average times, in hours, that could be expected under maximum possible flow conditions by either reducing the time in REACT or allowing FILL (1) are as follows:

TIME IN	REDUCED TIME IN REACT, hr	ALLOW FILL (1), hr
FILL (1)	0	0.12
FILL (2) + (3)	1.84	1.84
REACT	0.44	0.60
SETTLE	0.70	0.70
DRAW	0.70	0.66
IDLE	0	0

Neither configuration would have been successful in June 1981. Thus the hydraulic limitation of the Culver SBR was exceeded.

Biological nitrogen removal. Analyses made on NH_4-N and NO_x-N revealed that there was very little change in the concentration of either parameter for any period during an entire cycle. In other words, nitrification and denitrification took place simultaneously. Nitrogen removal in Notre Dame laboratory bench-scale SBRs always took place sequentially because high DO and low DO conditions were easy to achieve and maintain in the ideally mixed laboratory reactors. At Culver, a high DO suitable for nitrification is present when mixed liquor is pumped through the aerated jet. After passing through the jet, the mixed liquor is exposed to localized low DO conditions which allows for denitrification to take place.

Energy usage. Power consumption at Culver can be broken-down as follows:

Item	% Total SBR Power Consumption
Mixing	49
Aeration (blowers)	40
Decanting	10
Chlorination	1
Total	100

Estimated consumption values, in kWh/d, from November 1980 through February 1981 are presented below.

	NT	ST	TOTAL
NOV	198	179	377
DEC	204	175	379
JAN	203	191	394
FEB	177	168	345
AVG	196	178	374

This power consumption could probably have been reduced to approximately 150 kWh per day per tank by eliminating some or replacing (with lower power pumps) all of the jet aerators without exceeding the effluent limitations of 10 g/m^3 BOD_5 and 10 g/m^3 SS. More energy would have to be supplied for nitrification if that were an effluent limitation for discharge.

Winter operating conditions. A scum was present on each reactor throughout most of the study period. Since decant was from below the surface, operating difficulties did not occur unless extreme winter conditions developed. In this case, the scum would freeze and the float switches would lift vertically without tipping. The frozen scum, if thick enough, would also hamper the operation of the decanter in the North Tank. The decanter in the South Tank was sufficiently massive to overcome any icing difficulties. This problem could have been eliminated at Culver if skimming devices had

been installed. Without the scum, any ice that would have formed during SETTLE and DRAW could have been broken-up with mixing (and possibly aeration) during IDLE during extremely severe temperature conditions. Alternatively, a cover over the tanks in more northern climates might serve as a useful solution.

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11. Goronszy, M.C., "Intermittent Operation of the Extended Aeration Process for Small Systems,"

12. Ketchum, L.H., R.L. Irvine and P.C. Liao, "First Cost Analysis of Sequencing Batch Biological Reactors," and

13. Ketchum, L.H. and P.C. Liao, "Tertiary Chemical Treatment for Phosphorus Reduction Using Sequencing Batch Reactors."

APPENDIX I

SUMMARY OF CULVER SBR OPERATING DATA

TABLE 1. Summary of Culver SBR Operating Data - May 1980 (Hours:Minutes)

DATE	NORTH TANK							SOUTH TANK						
	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE
5/12														
5/13														
5/14														
5/15		3:00	9:03	1:48	3:00	4:26	0:43		4:40	7:17	5:39	3:00	3:24	0:00
5/16														
5/17														
5/18														
5/19														
5/20		5:50	6:32	4:57	2:15	2:38	1:48		7:46	3:52	3:23	3:00	3:36	2:23
5/21		6:04	5:15	4:18	3:00	3:35	1:48		6:19	6:22	3:51	2:15	2:42	2:31
5/22		5:35	6:14	5:14	2:15	2:36	2:06		8:04	4:07	3:00	3:00	3:33	2:16
5/23		6:16	5:55	4:24	3:00	3:17	1:08		6:43	5:06	3:38	3:00	3:32	2:01
5/24		5:43	5:33	5:12	3:27	3:09	0:56		7:41	5:03	3:11	3:00	3:23	1:42
5/25		7:13	5:05	4:02	2:33	3:30	1:37		5:00	6:42	4:10	3:00	3:22	1:46
5/26														
5/27														
5/28														
5/29		5:45	5:34	3:40	3:00	3:10	2:51		4:40	8:01	2:11	3:24	3:18	2:26
5/30	0:37	5:34	6:01	4:53	2:25	2:22	2:08		6:19	5:29	2:17	2:34	3:32	3:49
5/31		6:50	5:34	3:45	2:50	3:41	2:20		4:40	6:56	3:54	2:15	2:29	3:46
AVERAGE May 12-31 1980	0:04	5:47	6:05	4:25	2:46	3:14	1:39	0:00	6:11	5:53	3:32	2:51	3:17	2:16

TABLE 2. Summary of Culver SBR Operating Data - June 1980 (Hours:Minutes)

DATE	NORTH TANK							SOUTH TANK						
	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE
6/1		5:57	6:02	3:22	3:00	3:10	2:29		5:51	7:10	2:31	3:45	3:46	1:57
6/2	0:41	5:27	5:57	1:38	4:33	4:38	1:06	0:48	1:16	7:51	1:59	4:30	4:09	1:27
6/3		5:55	5:04	2:55	3:53	4:22	1:52		3:36	9:25	3:09	3:00	3:15	1:35
6/4														
6/5														
6/6		6:25	6:39	2:27	2:15	2:39	3:10		3:47	7:14	3:01	3:00	2:44	4:12
6/7		6:10	6:59	2:20	2:12	2:42	3:52		3:53	7:13	3:27	2:12	2:54	4:30
6/8														
6/9														
6/10														
6/11														
6/12														
6/13														
6/14														
6/15														
6/16	0:31	4:58	9:10	1:57	3:00	3:36	3:46		5:56	7:22	1:43	2:14	2:17	5:27
6/17		5:50	7:30	1:07	2:50	2:42	3:47		4:16	6:10	2:15	3:00	2:52	5:27
6/18		5:52	7:08	0:40	2:22	3:17	5:30		3:57	7:03	1:58	3:00	3:14	4:48
6/19	0:24	3:51	7:51	1:04	3:00	3:27	5:21		3:46	8:06	0:53	3:00	3:10	4:57
6/20														
6/21														
6/22		3:44	7:37	1:12	3:00	3:21	4:52		4:37	8:02	0:52	2:21	3:08	4:51
6/23														
6/24														
6/25														
6/26		3:49	10:01	1:04	2:15	2:53	4:00		2:32	7:38	1:31	3:00	3:35	5:53
6/27		6:02	6:53	0:35	3:00	3:40	3:51		2:33	8:33	1:21	3:00	3:04	5:27
6/28		3:58	8:02	1:03	3:00	3:51	4:02		4:19	7:34	1:28	2:15	3:00	5:24
6/29		3:26	9:30	1:05	2:15	2:52	5:01		3:52	7:02	1:50	3:00	3:28	4:38
6/30		2:21	8:02	1:24	3:00	3:28	5:35		4:01	8:46	1:47	2:12	2:37	3:44
AVERAGE JUNE 1980	0:07	4:56	7:16	1:39	2:54	3:20	3:48	0:01	3:56	7:41	2:00	2:54	3:09	4:17

TABLE 3. Summary of Culver SBR Operating Data - July 1980 (Hours:Minutes)

DATE	NORTH TANK							SOUTH TANK						
	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE
7/1	-	2:48	9:27	1:55	2:15	2:20	5:15	-	5:17	6:28	1:59	3:00	3:25	3:51
7/2	-	2:18	8:17	1:47	3:00	3:40	4:58	-	4:54	8:31	1:42	2:15	2:41	3:57
7/3	-	2:47	10:00	1:51	2:15	2:32	4:35	-	4:22	6:51	2:02	3:00	3:39	4:06
7/4	-	1:14	7:07	1:16	3:00	3:14	5:49	-	3:54	9:25	2:10	2:27	2:23	3:21
7/5	-	2:18	7:18	1:05	2:14	2:20	8:25	-	3:30	11:24	1:39	2:03	2:04	3:20
7/6	-	2:43	8:31	1:32	3:00	2:58	5:14	-	4:29	8:15	1:59	3:00	3:01	3:16
7/7	-	2:05	9:15	1:51	3:00	3:10	4:39	-	4:42	7:58	1:22	3:00	3:06	3:52
7/8	-	2:25	8:51	1:39	3:00	3:10	4:55	-	4:47	7:57	1:45	2:59	3:08	3:24
7/9	-	2:12	10:14	1:21	3:00	2:21	4:30	-	4:08	7:06	1:18	3:45	3:49	3:34
7/10	-	2:43	8:48	1:20	3:00	3:15	4:54	-	3:52	8:37	1:54	2:55	2:22	4:20
7/11	-	1:55	9:22	1:40	3:00	3:12	4:51	-	4:56	7:47	1:16	2:20	2:59	4:42
7/12	-	2:32	9:42	1:42	2:28	2:11	5:25	-	3:45	8:01	1:18	3:00	3:05	4:31
7/13	-	2:57	8:40	1:26	2:47	3:10	5:00	-	4:10	8:13	2:14	3:00	2:36	3:49
7/14	-	2:21	8:37	1:39	3:00	3:16	5:06	-	4:51	8:11	1:51	2:15	2:39	4:13
7/15	-	3:37 *	8:45	1:36	3:00	3:00*	4:02 *	-	4:46	7:43 *	2:20*	3:00	3:08	3:33
7/16	-	2:49	9:32	1:45	2:15	2:15	5:24	-	4:21	7:18	2:06	3:00	3:10	4:05
7/17	-	2:19	8:12	1:54	3:00	3:19	5:16	-	4:52	8:37	1:35	2:15	2:14	4:27
7/18	-	2:21	8:52	1:38	3:00	3:05	5:02	-	4:53	8:52	1:41	3:00	3:11	2:23
7/19	-	2:25	9:15	1:24	3:00	3:06	4:50	-	4:38	7:42	1:41	2:59	3:46	3:14
7/20	-	2:21	9:27	1:37	2:54	2:19	5:22	-	4:38	7:14	1:31	3:00	3:04	4:11
7/21**	-	2:56	6:48	1:14	2:21	2:43	5:57	-	3:25	8:50	2:01	3:45	2:48	1:51
7/22**	-	1:26	5:32	1:31	3:00	3:11	3:10	-	4:00	7:18	1:00	2:47	1:49	1:22
7/23	-	2:02	9:14	1:54	3:00	3:10	4:40	-	4:46	7:58	1:29	3:00	3:02	1:45
7/24	-	2:42	10:29	1:45	2:43	2:11	4:10	-	4:35	6:14	2:01	3:00	2:56	5:14
7/25	-	3:56	7:57	1:12	2:32	3:18	5:05	-	3:40	8:27	2:41	3:00	2:58	3:14
7/26	-	2:24	9:07	1:29	3:00	3:11	4:49	-	4:30	7:59	1:54	2:24	2:13	5:00
7/27	-	2:11	9:24	1:38	2:59	3:05	4:43	-	4:16	7:49	1:35	3:00	3:00	4:00
7/28	-	2:13	8:54	1:19	3:00	3:05	5:29	-	4:01	8:52	1:17	3:00	2:55	1:35
7/29	-	2:17	8:55	1:42	3:00	3:10	4:36	-	4:30	7:58	1:56	3:00	3:04	1:32
7/30	-	2:28	9:10	1:38	3:00	2:40	5:04	-	4:59	7:21	1:48	3:00	3:10	1:40
7/31	-	3:15	9:17	1:37	2:11	2:38	5:00	-	3:29	7:59	2:04	3:28	3:12	1:48
AVERAGE JULY 1980	-	2:45	8:58	1:45	2:49	2:54	5:09	-	4:25	8:03	1:48	2:52	2:58	3:52

* approximate total time due to 2:57 stop on microprocessor

** incomplete data

TABLE 4. Summary of Culver SBR Operating Data - August 1980 (Hours:Minutes)

DATE	NORTH TANK							SOUTH TANK						
	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE
8/1	-	2:49	8:49	1:39	2:59	3:13	4:31	-	3:45	8:37	2:02	3:00	3:07	3:29
8/2	-	2:36	7:22	1:30	3:00	3:07	6:25	-	4:18	9:44	1:56	2:14	2:13	3:35
8/3	-	2:57	9:40	1:35	2:15	2:11	5:22	-	4:12	7:01	2:08	3:00	2:55	4:34
8/4	-	2:46	7:51	1:27	3:00	3:02	5:54	-	4:37	8:46	2:13	2:15	2:10	3:59
8/5	-	3:08	9:40	1:20	2:15	2:10	5:27	-	3:49	7:23	2:34	3:00	3:05	4:09
8/6	-	3:13	8:22	1:36	2:15	2:13	6:21	-	4:02	8:23	3:09	2:15	2:11	4:00
8/7	-	2:07	8:13	2:03	3:28	2:42	5:27	-	5:08	8:32	2:06	3:00	2:52	2:22
8/8	-	2:39	8:03	1:12	3:17	3:51	4:58	:23	3:37	9:18	2:41	3:00	2:45	2:16
8/9	-	1:16	7:36	:54	2:59	3:12	8:03	:25	3:05	11:38	1:19	3:27	2:31	1:35
8/10								-	3:19	11:44	1:31	3:05	2:47	1:34
8/11	-	2:10	10:40	1:31	3:00	2:49	3:50	-	3:35	7:35	1:20	4:03	3:19	4:08
8/12	-	2:26	7:56	4:36	3:18	3:05	2:39	:36	6:57	6:05	1:37	3:01	2:21	3:23
8/13 *														
8/14 *														
8/15	-	3:20	9:16	2:15	2:53	2:40	3:36	-	3:38	7:46	1:57	3:08	2:24	5:07
8/16	-	2:32	10:57	2:11	2:22	3:03	2:55	-	3:15	7:16	1:56	3:00	2:37	5:56
8/17	-	2:31	9:36	3:59	3:00	3:11	1:43	-	4:48	7:05	1:26	3:00	2:37	5:04
8/18	-	2:55	9:35	2:50	3:01	3:05	2:34	-	4:07	7:23	1:38	3:00	2:39	5:13
8/19 **								-	2:35	7:11	4:36	4:09	2:57	2:32
8/20	:59	1:04	7:50	2:19	4:00	4:02	3:46	1:00	4:33	7:47	:08	4:00	1:55	4:37
8/21	:30	1:32	8:57	1:29	2:15	1:31	7:46	-	2:17	4:10	1:00	9:54	2:33	4:06
8/22	:10	1:22	10:01	2:31	3:45	2:31	3:40	-	4:44	7:43	:48	3:00	2:35	5:10
8/23	-	1:56	10:29	2:33	2:15	1:37	5:10	-	3:57	7:38	1:31	3:00	2:30	5:24
8/24	-	1:45	9:21	3:03	3:00	1:53	4:58	-	4:37	8:17	1:25	3:00	2:13	4:28
8/25	-	1:01	8:43	2:17	3:00	2:32	6:26	-	5:47	8:29	:48	2:15	2:16	4:25
8/26	-	:53	9:47	2:30	2:15	1:19	7:16	-	3:27	9:53	:43	3:45	2:29	3:43
8/27	-	:59	15:08	1:49	2:15	1:38	2:11	-	2:22	5:31	:43	3:45	2:45	8:54
8/28	-	2:01	8:21	2:01	3:45	2:31	5:21	-	4:32	9:06	1:36	3:00	2:43	3:04
8/29	-	1:32	9:23	3:09	2:31	2:05	5:20	-	4:02	9:03	1:03	3:00	2:57	3:55
8/30	-	1:49	7:41	3:18	3:55	3:14	4:03	-	5:13	9:10	1:09	3:00	2:28	3:00
8/31 *														
AVERAGE	:04	2:08	9:12	2:13	2:55	2:38	4:50	:06	4:10	8:01	1:34	3:19	2:35	4:13

* No data: microprocessor outage due to electrical storm.

** North tank drained for installation of new decant system.

TABLE 5. Summary of Culver SBR Operating Data - September 1980 (Hours:Minutes)

DATE	NORTH TANK							SOUTH TANK						
	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE
9/1	-	1:16	9:36	2:58	3:32	2:28	4:10	-	3:27	9:42	:54	3:00	2:52	4:05
9/2	-	1:35	10:01	2:06	3:58	3:46	2:34	-	2:49	9:36	1:06	4:30	3:42	2:17
9/3														
9/4														
9/5														
9/6														
9/7														
9/8														
9/8														
9/10	-	1:30	9:42	2:32	3:00	2:35	4:41	-	3:08	9:40	:53	3:37	2:51	3:51
9/11	-	1:06	10:05	3:09	2:59	2:41	4:00	-	3:59	8:50	:49	2:23	2:44	5:15
9/12	-	1:31	9:07	2:50	3:00	2:38	4:54	-	4:01	9:21	1:13	3:00	2:50	3:35
9/13	-	1:25	9:28	2:47	3:00	2:36	4:44	-	4:28	8:39	1:02	3:00	2:47	4:04
9/14														
9/15														
9/16														
9/17														
9/18	-	1:49	9:36	2:45	3:00	2:50	4:00	-	4:13	8:22	1:14	3:06	3:01	4:04
9/19	-	1:16	9:43	3:08	3:00	2:50	4:03	-	4:30	8:31	:42	2:54	3:01	4:22
9/20	-	1:31	10:07	3:36	2:45	2:00	4:01	-	4:49	7:33	1:05	3:00	2:51	4:42
9/21	-	1:59	9:18	2:29	2:30	2:32	5:12	-	3:11	9:32	1:12	3:00	2:56	4:09
9/22	-	1:28	8:29	3:09	2:59	2:47	5:08	-	4:31	9:32	1:02	2:15	2:10	4:30
9/23	-	1:50	9:23	3:17	3:00	2:39	3:51	-	4:53	7:54	1:22	3:00	3:03	3:48
9/24														
9/25	-	1:40	9:44	3:12	3:00	2:45	3:39	-	3:51	8:45	1:12	3:00	2:59	4:11
9/26	-	1:25	9:29	2:59	3:45	2:51	3:31	-	3:57	9:09	1:06	3:00	2:59	3:49
9/27	-	1:48	9:49	2:30	2:15	2:31	5:07	-	3:23	9:00	1:16	2:58	2:59	4:24
9/28	-	1:45	9:01	2:53	3:00	2:30	4:49	-	4:14	8:58	1:08	3:00	2:23	4:17
9/29	:10	1:44	9:58	3:01	3:00	2:33	3:34	-	3:21	8:47	:58	3:00	2:39	5:15
9/30	-	1:15	10:37	2:35	2:15	1:57	5:21	-	4:09	7:59	:51	2:15	2:48	5:58
AVG.	:0.5	1:33	9:38	2:51	3:00	2:38	4:18	-	3:56	8:51	1:04	3:00	2:52	4:15

TABLE 6. Summary of Culver SBR Operating Data - October 1980 (Hours:Minutes)

DATE	NORTH TANK							SOUTH TANK						
	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE
10/1	-	2:07	8:13	3:07	3:00	2:51	4:42	-	4:18	9:22	1:11	2:43	2:08	4:18
10/2	-	1:38	10:32	3:16	2:15	2:03	4:16	-	4:22	7:28	1:10	2:32	3:01	5:27
10/3	-	2:05	9:29	2:22	3:00	2:50	4:14	-	3:37	8:49	1:24	3:00	2:51	4:19
10/4	-	1:33	9:38	3:31	3:00	2:14	4:04	-	5:02	7:47	1:10	2:15	2:03	5:43
10/5	-	2:05	8:52	2:40	2:15	2:24	5:44	-	3:41	9:22	1:25	2:59	2:29	4:04
10/6	-	1:34	9:48	3:19	2:35	2:02	4:42	-	4:51	7:47	1:07	2:15	2:45	5:15
10/7	-	2:42	9:28	2:49	2:40	2:52	3:29	-	3:33	8:17	1:57	3:00	2:27	4:46
10/8	-	1:48	10:31	3:57	2:53	1:59	2:52	-	4:06	7:35	1:39	2:15	2:11	6:14
10/9	-	2:45	10:00	3:04	2:20	2:43	3:08	-	3:28	7:47	2:12	2:59	2:30	5:04
10/10	-	2:29	9:02	3:47	2:59	2:13	3:30	-	5:01	7:28	1:08	2:15	2:17	5:51
10/11	-	4:12	7:27	2:25	2:16	2:48	4:32	-	3:23	8:38	1:55	2:15	2:07	5:42
10/12	-	3:57	9:47	2:37	2:15	2:10	3:14	-	3:34	6:42	1:38	3:00	2:45	6:21
10/13														
10/14	-	3:27	8:44	3:11	2:15	2:01	4:22	-	4:37	7:12	1:23	2:54	2:52	5:02
10/15	-	3:31	6:10	3:31	2:15	2:12	6:21	-	6:50	7:29	1:13	1:30	1:17	5:41
10/16	-	4:05	8:36	2:43	2:15	2:15	4:06	-	7:00	4:19	1:41	2:15	2:21	6:24
10/17	-	4:25	8:01	1:57	3:00	3:02	3:35	-	4:52	6:42	1:36	3:00	3:27	4:23
10/18	-	4:41	7:34	2:32	2:15	2:13	4:45	-	5:55	5:50	1:36	1:00	2:50	4:49
10/19	-	2:55	9:28	2:27	2:15	2:15	4:40	-	6:04	5:33	1:48	2:15	2:19	5:41
10/20	0:06	3:20	6:29	2:25	3:00	3:30	5:10	-	6:39	7:26	1:21	2:37	2:35	3:22
10/21	-	3:04	9:55	3:13	2:15	2:04	3:29	-	6:58	4:03	0:46	2:38	3:15	6:20
10/22	-	3:54	6:45	2:48	2:15	2:12	6:06	-	6:28	6:53	2:16	2:15	2:16	3:52
10/23	-	2:43	8:26	3:36	2:20	2:12	4:43	-	7:49	5:02	2:21	2:14	3:00	3:34
10/24	-	4:15	8:32	2:00	2:55	2:59	3:19	-	5:10	6:01	1:27	3:00	3:29	2:51
10/25	-	4:22	6:58	2:14	3:00	2:53	4:33	-	5:55	6:45	1:47	2:15	2:33	2:45
10/26	-	2:40	9:23	2:53	2:15	2:32	4:17	-	6:27	5:30	2:15	3:00	3:29	3:19
10/27	-	3:43	8:31	2:16	3:00	3:24	3:06	-	5:52	5:54	3:19	3:00	3:27	2:28
10/28	-	3:37	8:29	2:35	3:00	3:18	3:01	-	6:06	5:48	3:00	3:00	3:30	2:36
10/29	-	2:42	7:15	2:58	3:00	3:29	4:36	-	7:00	7:03	2:06	2:15	2:28	3:08
10/30	-	3:13	8:58	3:14	2:51	2:25	3:19	-	6:56	4:53	2:47	2:59	2:55	3:10
10/31	-	4:09	7:51	2:17	2:24	3:25	3:54	-	5:02	6:58	1:24	3:00	2:35	3:01
AVERAGE	0:00	3:08	8:38	2:51	2:46	2:45	4:12	0:00	5:21	6:53	1:56	2:37	2:41	4:32

TABLE 7. Summary of Culver SBR Operating Data - November 1980 (Hours:Minutes)

DATE	NORTH TANK							SOUTH TANK						
	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE
11/1		2:19	9:16	3:06	2:15	2:23	4:41		7:04	5:21	1:53	2:15	3:27	4:00
11/2		3:05	8:37	3:02	2:15	2:13	4:48		6:35	5:43	2:22	2:15	2:32	4:33
11/3		2:32	8:46	2:21	3:00	2:57	4:24		6:00	6:42	1:43	3:00	3:29	3:06
11/4		1:49	7:46	3:16	3:00	3:01	5:08		8:01	6:24	1:25	2:15	2:39	3:16
11/5		2:21	10:04	3:40	2:15	2:01	3:39		6:31	4:54	1:39	3:00	3:33	4:13
11/6		2:59	7:39	2:19	3:00	3:03	5:00		6:08	7:14	2:21	2:38	2:36	3:03
11/7		1:55	8:57	3:26	3:00	2:50	3:52		8:30	4:38	1:29	2:37	3:30	3:16
11/8		2:49	9:01	2:43	2:15	2:16	4:56		5:59	7:11	1:53	3:00	2:46	3:11
11/9		1:51	8:55	3:30	3:00	2:20	4:24		7:19	5:55	1:24	2:15	3:17	3:55
11/10		3:29	8:11	2:21	2:15	3:02	4:42		5:25	6:55	2:46	2:59	2:40	3:15
11/11														
11/12		2:00	8:00	5:00	3:00	2:39	3:21		7:05	6:55	1:42	2:15	2:25	3:38
11/13		4:12	8:45	3:37	2:15	1:59	3:12		5:37	5:26	2:49	3:00	3:24	3:44
11/14		4:38	6:13	4:45	3:00	2:42	2:42		6:06	7:03	1:59	3:00	2:43	3:09
11/15		3:19	9:01	3:45	2:15	2:06	3:34		5:41	5:59	1:38	2:15	3:16	5:11
11/16		4:54	6:57	4:33	2:15	2:10	3:11		5:54	6:35	2:21	2:15	2:14	4:41
11/17		4:55	7:05	3:46	3:00	2:54	2:20		4:48	7:12	1:01	2:59	3:26	4:34
11/18		4:49	6:49	4:46	2:15	2:12	3:09		6:28	5:54	2:16	2:15	2:35	4:32
11/19		7:25	5:24	4:08	2:15	2:12	2:30		4:48	6:23	2:36	2:15	2:35	5:33
11/20		6:35	4:02	4:12	3:00	2:58	3:13		5:35	7:48	2:07	2:15	2:35	3:40
11/21		8:17	6:04	3:31	2:15	2:13	1:40		4:21	5:18	2:32	3:00	3:30	5:19
11/22		5:30	6:58	3:33	2:15	2:11	3:33		5:34	5:58	1:52	2:15	2:31	5:50
11/23		5:53	4:50	4:55	3:00	2:37	2:45		6:25	6:52	2:05	2:14	2:37	3:47
11/24		4:52	9:09	2:55	2:15	2:33	2:16		2:44	7:15	2:40	2:59	3:28	4:54
11/25		2:38	7:56	5:05	2:56	2:16	3:09		7:56	5:30	2:24	2:15	2:34	3:21
11/26		3:38	9:15	4:09	2:19	2:45	1:54		5:08	5:59	2:43	3:00	3:26	3:44
11/27		2:55	7:41	5:23	3:00	2:48	2:13		7:07	6:17	2:26	2:14	2:30	3:26
11/28		1:20	8:54	4:34	3:00	2:31	1:41		6:35	5:11	2:15	3:44	3:29	2:46
11/29	0:28	3:16	7:42	4:53	3:00	2:33	2:08		6:51	5:43	2:12	2:15	2:57	4:02
11/30		3:13	9:06	4:20	2:13	2:15	2:53		6:25	5:16	2:11	2:59	3:16	3:33
AVERAGE	0:01	3:50	7:50	3:51	2:37	2:30	3:21		6:10	6:10	2:06	2:16	2:58	3:58

TABLE 8. Summary of Culver SPR Operating Data - December 1980 (Hours:Minutes)

DATE	NORTH TANK							SOUTH TANK						
	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE
12/1		2:32	8:26	4:36	3:45	3:09	1:32		6:30	6:32	1:56	3:00	2:58	3:04
12/2		3:35	8:47	3:37	3:41	2:38	1:42	0:40	5:06	5:52	2:55	3:20	2:52	3:15
12/3		3:10	8:52	3:39	3:00	3:12	2:07		4:49	7:09	2:21	2:42	3:44	3:15
12/4		3:12	8:06	3:42	2:59	2:35	3.26		6:39	6:03	1:41	2:58	3:47	2:52
12/5		3:52	8:47	3:40	2:15	2:43	2:43		5:13	6:08	2:04	3:00	3:48	3:47
12/6		3:39	6:52	2:59	3:00	2:53	4:37		5:38	7:51	2:34	2:15	2:46	2:56
12/7		4:13	9:10	2:48	2:15	2:14	3:20		4:37	6:00	2:42	3:00	3:46	3:55
12/8	0:21	3:24	8:54	3:24	3:45	3:31	0:41		5:31	5:50	1:49	3:45	4:42	2:23
12/9		3:36	7:25	3:56	3:44	3:45	1:34		6:13	6:46	2:32	3:00	3:42	1:47
12/10		3:55	8:18	3:38	2:59	2:58	2:12		5:50	5:57	2:31	3:45	4:06	1:51
12/11		5:35	6:04	3:28	3:00	3:13	2:40		5:37	6:44	2:32	3:00	3:41	2:26
12/12		5:12	5:54	3:41	3:00	3:02	3:11		6:01	6:53	2:38	2:38	3:27	2:23
12/13		4:44	7:17	3:50	2:54	2:18	2:57		6:16	5:43	1:45	2:36	3:43	3:57
12/14		6:09	6:03	2:44	2:20	3:04	3:40		4:23	7:25	2:16	3:00	3:32	3:24
12/15	0:17	5:07	7:50	2:46	3:00	2:59	2:01		6:44	4:02	1:59	3:00	4:07	4:08
12/16		5:22	6:27	2:28	3:45	3:46	2:12		8:42	3:29	1:54	3:00	3:22	3:33
12/17		7:01	6:27	1:20	2:15	2:19	4:38	0:35	6:06	3:51	3:08	3:00	3:26	3:54
12/18		5:11	7:08	2:35	2:15	2:11	4:40		7:03	4:38	2:25	2:15	2:26	5:13
12/19		6:46	7:33	1:31	2:15	2:20	3:35		4:13	5:28	2:55	2:15	2:01	7:08
12/20*														
12/21*														
12/22		5:14	8:35	0:47	2:59	2:28	3:57	0:02	4:21	5:48	1:46	2:15	2:45	7:03
12/23		6:17	5:30	3:04	2:15	2:23	4:31		4:42	7:31	2:48	2:37	2:23	3:59
12/24		6:23	7:12	2:18	2:14	2:14	3:39		4:16	6:09	2:43	2:38	2:29	5:45
12/25		6:33	5:44	2:48	2:15	1:56	4:44		5:34	6:09	1:56	2:14	3:11	4:56
12/26		4:44	7:56	2:51	3:00	2:27	3:02		5:39	5:41	1:25	2:15	2:18	6:42
12/27		5:57	7:03	2:12	2:15	2:26	4:07		4:17	6:43	2:06	2:15	2:17	6:22
12/28 **														
12/29	0:24	5:56	6:16	3:50	3:00	2:12	2:22		4:58	6:26	1:11	3:00	2:29	5:56
12/30		5:13	7:51	3:12	2:15	1:55	3:34		4:38	6:18	1:45	2:15	1:55	7:09
12/31		5:02	5:19	4:03	3:00	2:32	4:04		5:42	7:57	1:42	2:15	1:53	4:31
AVERAGE	0:02	4:55	7:21	3:03	2:50	2:42	3:07	0:03	5:33	6:06	2:11	2:45	3:08	4:12

*switch malfunction due to frozen foam on tank

**check valve freeze-up on decant line

TABLE 9. Summary of Culver SBR Operating Data - January 1981 (Hours:Minutes)

DATE	NORTH TANK							SOUTH TANK						
	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE
1/1		5:59	7:50	1:48	2:15	1:57	4:11		3:30	6:41	1:59	3:00	2:38	6:12
1/2		5:00	4:32	3:36	2:59	2:29	5:24		6:34	7:54	1:22	2:15	1:53	4:02
1/3		4:58	5:57	2:52	2:15	1:53	6:05		5:09	7:56	1:18	2:15	2:12	5:10
1/4		5:19	5:58	2:39	2:15	1:54	5:55		5:20	7:23	1:12	2:15	2:06	5:44
1/5		5:52	7:05	2:37	3:00	2:33	2:53		5:01	6:02	1:35	3:45	3:45	3:52
1/6		5:34	4:39	2:41	3:00	2:33	5:33		5:12	8:35	1:39	2:38	2:10	3:46
1/7	0:06	3:18	6:23	3.48	3:00	2:31	4:54		6:54	7:19	0:54	2:37	2:52	3:24
1/8		4:46	7:11	2:56	3:00	2:18	3:49		5:27	6:36	1:16	3:00	3:02	4:39
1/9 *														
1/10		3:20	8:53	3:02	2:39	1:44	4:22		5:59	5:48	1:28	3:00	2:32	5:13
1/11		4:25	7:15	2:20	2:36	2:19	5:05		4:56	7:24	2:07	3:00	2:31	4:02
1/12		3:31	7:22	2:52	2:59	2:24	4:52		5:11	7:46	1:56	3:00	2:29	3:38
1/13		1:55	7:39	3:09	2:59	2:20	5:58		5:20	9:06	1:11	2:15	2:09	3:59
1/14		3:41	7:17	2:52	2:15	1:43	6:12		6:57	6:05	1:40	2:46	1:59	4:33
1/15		2:18	8:12	2:57	3:00	2:15	5:18		4:55	8:35	1:05	3:11	2:41	3:33
1/16		3:00	7:55	2:39	3:00	2:19	5:07		5:02	8:03	1:18	3:03	3:28	3:06
1/17		3:22	8:36	2:18	2:59	2:23	4:22		4:32	7:30	1:36	3:00	2:38	4:44
1/18		3:02	7:40	3:11	3:00	2:25	4:42		5:24	7:54	1:32	3:00	2:25	3:45
1/19		3:11	8:56	2:11	3:00	2:23	4:19		4:32	7:21	2:07	2:59	2:57	4:04
1/20		3:34	6:20	3:11	3:00	2:26	5:29		5:25	8:41	1:45	2:18	1:57	3:54
1/21		2:58	8:03	3:43	3:00	1:50	4:26		6:22	6:37	1:27	2:57	2:42	3:55
1/22		4:25	7:24	2:28	2:14	2:22	5:07		4:17	7:54	2:03	3:00	2:42	4:04
1/23		3:50	7:13	2:56	3:00	2:22	4:39		5:05	7:52	1:32	3:00	2:39	3:52
1/24		3:47	6:43	3:03	3:00	2:24	5:03		5:35	7:55	1:44	2:45	1:59	4:02
1/25		3:50	7:41	3:06	3:00	2:21	4:02		5:24	7:05	1:48	2:58	2:38	4:07
1/26		4:00	9:22	3:14	3:00	2:24	2:00		5:20	5:18	2:03	3:17	3:02	5:00
1/27		3:46	8:23	3:23	2:59	2:25	3:04		5:25	6:26	1:49	2:59	2:36	4:45
1/28		3:32	8:19	2:44	3:00	2:24	4:01		4:51	7:21	1:59	3:00	2:37	4:12
1/29		4:00	8:27	2:42	3:00	2:21	3:30		4:48	6:45	1:40	3:00	2:30	5:17
1/30		3:02	8:38	2:33	3:00	2:23	4:24		4:40	7:40	1:30	3:00	2:40	4:30
1/31		3:34	7:24	2:52	3:00	2:19	4:49		5:25	7:35	1:41	3:00	2:17	3:40
AVERAGE	0:00	3:54	7:27	2:53	2:51	2:16	4:39		5:17	7:22	1:37	2:52	2:34	4:18

* check valve freeze-up

TABLE 10. Summary of Culver SBR Operating Data - February 1981 (Hours:Minutes)

DATE	NORTH TANK							SOUTH TANK						
	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE
2/1	0:22	3:40	7:16	2:46	3:45	3:05	3:06		5:11	7:31	1:53	3:00	2:32	3:53
2		3:35	8:43	2:40	3:00	2:39	3:23		4:42	7:00	1:32	3:45	3:05	3:56
3		3:18	7:50	2:28	3:00	2:40	4:44		5:04	7:48	1:42	3:00	2:49	3:37
4		3:00	8:08	2:48	3:00	2:37	4:27		5:07	7:45	1:37	3:00	2:39	3:52
5		4:39	5:53	2:53	2:59	2:38	4:58		5:20	8:08	2:09	2:15	2:00	4:08
6		5:06	7:00	3:09	2:34	1:57	4:14		5:55	5:59	1:15	3:00	2:40	5:11
7		6:02	6:18	2:34	1:56	1:57	5:13		4:22	7:18	1:47	2:15	1:54	6:24
8		5:30	5:28	2:01	3:00	2:36	5:25		4:39	8:23	1:17	2:15	1:56	5:30
9		6:32	6:23	2:53	2:52	1:57	3:23		5:18	5:47	1:47	3:00	2:40	5:28
10		6:29	4:55	2:25	3:08	3:05	3:58	0:30	3:49	8:17	1:44	3:28	2:15	3:57
11		6:14	5:16	2:37	3:00	2:42	4:11		4:49	7:41	2:54	2:32	2:33	3:31
12		6:11	6:27	2:57	2:15	2:17	3:53		4:52	6:30	1:22	3:00	2:38	5:38
13		5:00	5:25	2:57	3:00	2:56	4:42		5:21	8:14	1:22	2:57	1:59	4:07
14 *														
15		4:15	7:22	3:13	3:11	2:34	3:25		5:30	6:53	1:28	3:06	3:20	3:43
16		5:14	5:26	1:56	5:30	3:36	2:18	0:26	4:08	8:46	1:11	5:05	3:14	1:10
17		5:16	5:56	2:30	4:30	3:13	2:35	0:22	4:39	7:47	1:19	3:55	3:38	2:20
18		6:27	5:31	2:35	3:44	3:09	2:34		4:31	7:31	1:55	4:29	3:22	2:12
19 *														
20 *														
21 *														
22		3:04	8:07	2:42	3:00	2:25	4:42		4:38	8:11	1:56	3:00	2:18	3:57
23		2:55	9:24	3:17	3:10	2:16	2:58		5:22	6:19	2:16	3:45	2:55	3:23
24		3:00	8:12	2:48	3:35	2:39	3:46		5:24	7:24	1:19	3:44	2:55	2:54
25		2:21	7:59	3:19	3:45	2:45	3:51		5:56	7:44	1:39	3:00	2:20	3:21
26		3:38	9:04	2:59	2:59	2:14	3:06		5:14	6:04	2:10	3:45	2:54	3:51
27		2:56	8:08	3:48	3:00	2:13	3:55		6:01	6:55	1:46	3:00	2:21	3:57
28		2:46	7:34	2:49	3:45	2:48	4:18		5:14	8:06	1:36	3:00	2:22	3:24
AVERAGE	0:01	4:27	7:00	2:48	3:14	2:37	3:53	0:03	5:06	7:25	1:43	3:13	2:38	3:54

*Microprocessor down for approximately one hour.

TABLE 11. Summary of Culver SBR Operating Data - May 1981 (Hours:Minutes)

DATE	NORTH TANK							SOUTH TANK						
	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE
3/1		4:21	8:31	2:53	2:45	1:44	3:46		5:23	5:45	2:59	2:59	2:22	4:32
2		3:13	8:01	2:50	3:15	2:59	3:42		5:01	7:45	1:53	3:00	2:32	3:49
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														
15														
16														
17														
18														
19														
20														
21														
22														
23														
24														
25														
26														
27														
28														
29														
30														
31														
AVERAGE		3:47	8:16	2:52	3:00	2:21	3:44		5:12	6:45	2:26	3:00	2:27	4:10

TABLE 12. Summary of Culver SBR Operating Data - April 1981 (Hours:Minutes)

DATE	NORTH TANK							SOUTH TANK						
	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE	FILL(1)	FILL(2)	FILL(3)	REACT	SETTLE	DRAW	IDLE
4/1														
4/2														
4/3														
4/4														
4/5		1:50	8:27	1:09	2:15	1:31	8:48		4:29	9:14	0:42	2:37	2:03	4:55
4/6		2:00	10:42	1:51	2:15	1:32	5:40		4:26	6:52	0:27	2:38	2:42	6:55
4/7		1:21	9:52	1:34	3:00	2:05	6:08		4:48	7:59	0:46	3:00	2:41	4:46
4/8														
4/9		1:23	9:36	1:00	3:00	2:21	6:40		4:03	8:58	1:19	3:44	3:41	2:15
4/10		1:22	9:09	2:03	3:32	2:09	5:45		5:16	8:13	1:05	3:00	3:10	3:16
4/11		0:41	9:16	1:48	3:13	1:58	7:04		5:43	8:20	0:35	3:00	2:47	3:35
4/12	0:03	0:51	8:53	1:07	3:00	3:05	7:01		4:19	9:54	0:46	3:00	2:13	3:48
4/13														
4/14														
4/15	0:26	1:08	9:13	0:23	5:59	4:12	2:39	1:14	4:25	7:34	0:22	6:18	3:57	0:10
4/16	1:00	1:14	8:12	0:56	5:42	4:02	2:54	0:46	3:41	9:07	0:47	6:14	2:56	0:29
4/17		1:26	9:57	1:14	5:15	3:12	2:56	0:20	3:57	8:20	1:21	4:49	4:00	1:13
4/18		1:29	9:59	1:31	4:29	3:19	3:13		4:29	8:03	1:31	4:30	3:45	1:42
4/19		1:51	10:10	1:33	3:45	2:54	3:47		4:17	7:42	1:46	4:30	3:40	2:05
4/20		2:02	9:19	1:22	5:06	3:10	3:01		4:36	8:03	2:02	4:30	3:31	1:18
4/21		1:53	10:26	0:59	4:33	3:15	2:54		3:18	8:23	1:38	4:30	3:30	2:41
4/22														
4/23														
4/24														
4/25														
4/26														
4/27														
4/28														
4/29														
4/30														
AVG.	0:06	1728	9:30	1:23	3:56	2:45	4:53	0:10	4:25	8:20	1:05	4:01	3:11	2:48

APPENDIX II

SUMMARY OF CULVER SBR PERFORMANCE DATA

TABLE 1. Summary of Culver SBR Performance Data - May 1980

DATE	BOD5 (mg/ℓ)					SUSPENDED SOLIDS (mg/ℓ)					PHOSPHORUS (mg/ℓ)					NH_3 N (mg/ℓ as N)					NO_x-N (mg/ℓ as N)					MLSS (mg/ℓ)		SVI (ml/g)		FLOW (MGD)	PPT[A] (in)
	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	NT	ST	NT	ST		
5/12																															
5/13																															
5/14																										1550	1620	194	154		
5/15	136	118	3.3	17.9	2.4	114	66	7	20	19	9.0	9.5	0.4	1.0	1.2	20.0	18.0	17.0	16.1	18.0	6.6	9.8	0.7	1.4	1.6	2150	1960	198	150	.139	
5/16	148	134	0	0	4.5	104	116				5.5	7.8	6.6	6.6	1.8											1890	1940	151	150	.364	0.15
5/17																														.354	0.70
5/18																															
5/19						108	150	11	15	18	6.0	8.2	1.0	1.2	1.2											1960	1700		182	.289	0.05
5/20	200	126	21.1	8.5	1.9	126	60	8	12	15	7.2	4.2	0.4	0.6	1.2											1650	1520	152	155	.336	
5/21	240	135	8.2	14.5	0.0	124	70	7	8	11	7.0	4.8	0.4	0.6	0.6											1680	1400	137	143	.332	
5/22	162	132	7.6	10.0	1.5	138	68	10	7	11	5.8	5.2	0.5	0.4	0.6											1810	1650	138	152	.323	
5/23	172	144	6.1	19.1	1.0	162	130	8	11	9	6.2	6.8	0.4	0.5	0.5	20.0	22.4	19.0	19.6	19.6	8.2	7.7	0.6	0.6	1.3	2000	1860	135	124	.317	
5/24																										2030	1670	133	126	.253	0.20
5/25																														.301	
5/26																										1680	1800	143	138	.290	
5/27	175	142	5.6	2.1	0.0	136	84	6	7	7	7.5	6.8	0.2	0.2	0.3	25.8	21.8	21.8	19.6	20.6	6.6	6.3	0.4	0.4	1.4	1570	1470	153	126	.302	
5/28	144	125	5.2	5.8	2.6	102	62	4	4	8	6.5	7.8	0.3	0.3	0.5											1660	1680	145	128	.315	
5/29	135	105	4.2	5.4	0.9	94	56	5	6	6	5.5	5.2	0.2	0.3	0.5	23.8	20.6	20.6	20.6	20.0	5.8	6.3	0.6	0.6	1.1	1810	1780	155	107	.310	
5/30	125	72	2.7	2.4	2.6	116	62	3	5	8	6.2	3.5	0.2	0.2	1.0	18.0	16.6	16.6	14.9	16.6	6.2	7.0	0.4	0.4	1.1	1800	1860	147	136	.382	1.15
5/31																														.409	0.30
																														.346	0.25
AV.	164	123	6.4	8.6	1.9	120	84	6.5	9.6	11.	6.4	6.3	1.0	1.1	0.9	21.5	19.9	19.0	18.2	19.0	6.9	7.3	0.6	0.7	1.4	1710	1730	151	141	.327	

[A] Total Rainfall for Period May 12 - 31, 1980: 1.3 in.

RS = Raw Sewage
PE = Primary Effluent
NT = North Tank
ST = South Tank
FE = Final Effluent

TABLE 2. Summary of Culver SBR Performance Data - June 1980

DATE	BOD_5 (mg/ℓ)					SUSPENDED SOLIDS (mg/ℓ)					PHOSPHORUS (mg/ℓ)					NH_3-N (mg/ℓ as N)					NO_x-N (mg/ℓ as N)					MLSS (mg/ℓ)		SVI (mℓ/g)		FLOW (MGD)	PPT* (in)
	RS	FE	NI	SI	FE	RS	FE	NI	SI	FE	RS	FE	NI	SI	FE	RS	FE	NI	SI	FE	RS	FE	NI	SI	FE	NI	SI	NI	SI		
6/1																															
6/2						106	34	2	6	5	4.5	2.2	0.5	0.2	0.7	12.8	10.0	11.0	10.0	12.1						2070	1490	140	148	.501	2.00
6/3	79	49	4.2	3.0	0.0	56	12	0	4	0	5.5	4.2	0.3	0.5	0.4	9.7	9.7	10.7	9.7	9.1						1940	2710	129	89	.538	0.45
6/4	154	72	3.9	0.6	0.0	208	110	7	3	7	4.0	3.5	0.4	0.6	0.5	14.9	12.4	12.8	12.0	12.4	4.8	4.4	0.6	1.0	1.3	2210	1950	127	138	.415	
6/5	78	58	5.8	3.3	1.5	48	42	4	10	7	0.2	5.0	0.5	0.7	0.6	11.3	11.3	14.0	12.8	12.0	4.0	2.6	0.3	1.0	1.7	2090	1890	132	138	.373	
6/6	95	61	2.1			82	42	1	2	3	5.0	3.0	0.5	0.6	0.7	13.2	12.8	15.2	14.0	14.9	6.5	5.8	0.6	2.3	1.7	1820	1850	126	146	.311	
6/7																					4.4	5.1	0.0	2.0	0.6	1840	1800	125	150	.378	
6/8																														.318	
6/9						68	54	5		14	1.8	1.5	0.2		1.1															.281	0.15
6/10						128	58	8	2	5	3.3	3.0	0.4	0.3	0.3						4.0	5.1	0.6		1.0	2100		133		.304	0.17
6/11	104	65	3.8	1.2	2.5	68	42	2	2	11	4.5	3.0	0.3	0.3	0.6	14.3	13.6	15.2	14.3	14.3	7.7	7.0	0.6	1.0	1.3	1910	1290	171	160	.311	
6/12	95	94	3.8		1.2	54	66	3	2	11	3.5	3.0	0.4	0.2	0.7	14.3	15.2	16.1	15.7	15.7	6.6	7.3	0.4	1.3	0.7	2250	1510	149	142	.300	
6/13	166	106	3.1		0.6	172	198	2	4	10	7.2	10.5	0.4	0.4	0.7	20.7	16.6	17.5	14.7	16.1	5.5	4.4	0.4	1.7	1.3	2250	1590	160	138	.290	
6/14																					5.5	4.4	0.4	1.7	1.3	2180	1730	147	144	.310	
6/15																														.290	0.50
6/16						66	86	3	5	18	3.0	3.5	0.2	0.1	0.8	14.2	17.1	12.9	14.0	13.1	4.0	3.0	0.4	0.4	0.7	2640	1690	121	130	.320	0.82
6/17						80	64	5	1	11	5.5	4.5	0.3	0.3	0.7	12.0	12.3	13.1	11.7	12.9	5.8	6.9	3.6	2.0	1.6	2200	2030	130	138	.340	
6/18						124	118	3	7	7	3.5	5.0	0.8	0.4	0.4	14.2	13.1	14.0	13.7	14.0	6.6	4.0	1.3	1.0	2.0	2440	2080	107	132	.330	
6/19	265	122	8.4	3.8	1.4	312	86	10	4	7	5.8	4.5	0.5	0.3	0.4	16.6	14.9	14.2	15.2	15.2	3.6	4.7	0.7	0.7	1.0	2380	2280	120	118	.320	
6/20	118	106	14.0	14.8	4.2	158	84	7	5	11	5.2	3.8	0.3	0.3	0.8	14.0	13.1	15.2	15.8	16.6	3.3	3.3	0.4	0.7	0.7	2410	2300	124	122	.340	0.23
6/21																														.340	
6/22																														.300	
6/23																														.290	
6/24						132	94	9	7	10	5.5	4.5	0.4	0.4	0.7	20.0	21.8	18.5	20.0	20.7	12.4	5.8	0.7	1.0	1.3	2630	2220	122	119	.310	0.20
6/25	194	132	6.4	10.2	2.6	138	68	4	5	6	7.8	5.2	0.2	0.3	0.6	21.8	19.0	19.6	18.6	20.0	6.2	7.3	0.4	0.7	1.0	2470	1870	113	123	.300	
6/26	225	170	8.4	10.0	8.0	102	96	7	4	12	9.0	6.5	0.2	0.3	0.7	21.2	19.6	17.5	16.7	19.0	8.2	4.7	1.0	1.0	1.6	2720	1940	127	108	.320	
6/27	132	168	7.8	10.0	9.7	90	196	5	5	8	5.2	9.2	0.3	0.3	0.4	20.7	21.8	17.0	18.0	17.0	7.3	2.7	0.7	1.0	1.6	2600	1530	119	118	.340	0.17
6/28																														.300	
6/29																										2790	1820			.270	
6/30						92	62	3	5	10						19.6	20.7	18.5	18.7	19.6	5.6	3.1	0.7	0.7	1.5	2890	1750	131	109	.270	
AV.	142	100	6.0	6.3	2.9	115	83	4.9	4.3	8.6	4.8	4.6	0.4	0.4	0.6	15.6	14.7	15.0	14.4	15.0	5.9	4.9	0.8	1.4	1.2	2310	1870	131	131	.311	

* Total rainfall for June 1980: 4.7 in.

RS = Raw Sewage
FE = Primary Effluent
NI = North Tank
SI = South Tank
FE = Final Effluent

TABLE 3. Summary of Culver SBR Performance Data - July 1980

DATE	BOD_5 (mg/l)					SUSPENDED SOLIDS (mg/l)					PHOSPHORUS (mg/l)					NH_3-N (mg/l as N)					NO_x-N (mg/l as N)					MLSS (mg/l)		SVI (ml/g)		FLOW (MGD)	PPT (in)
	RS	PE	NI	SI	FE	RS	PE	NI	SI	FE	RS	PE	NI	SI	FE	RS	PE	NI	SI	FE	RS	PE	NI	SI	FE	NI	SI	NI	SI		
7/1	160	135	7.4	2.6	-	140	60	4	5	9	6.2	5.0	0.2	0.2	0.4	21.8	21.2	19.0	16.4	18.0	7.9	7.0	1.2	1.2	1.5	2190	2040	107	105	.279	
7/2	186	102	9.0	5.2	2.1	210	58	5	1	4	5.8	4.2	0.2	0.2	0.3	23.0	19.0	18.5	17.0	20.7	7.4	7.9	1.5	1.4	2.2	2510	2100	114	86	.307	
7/3	230	106	7.6	6.4	4.0	186	68	6	3	7	7.2	5.8	0.1	0.1	0.6	24.2	21.2	17.0	16.5	19.0	9.3	7.4	2.2	0.4	1.5	2210	1760	113	108	.310	[illegible]
7/4																										2690	1650	113	118	.259	.15
7/5																														.267	
7/6																										3600	1640	72	103	.313	
7/7									4																		1740		109	.330	
7/8	169	170	6.2	1.6	-	124	142	3	1	7	5.5	9.5	0.1	0.4	0.4	23.0	20.0	18.0	15.8	17.6	10.3	3.8	0.4	0.4	1.2	2130	1710	108	105	.333	
7/9	220	153	7.8	1.6	-	190	86	4	3	7	6.2	4.5	0.2	0.1	0.3	21.8	19.0	15.2	14.9	15.2	8.3	9.8	0.4	0.4	1.2	2470	1830	121	104	.350	.75
7/10	166	140	9.6	12.2	0.4	128	102	5	6	7	5.5	5.5	0.2	0.5	0.8	25.8	21.2	14.3	14.9	15.2	8.8	5.3	1.2	0.4	1.5	2290	1830	114	109	.327	
7/11	162	108	6.6	6.8	-	100	72	5	8	7	6.0	4.5	0.2	0.3	0.6	26.4	21.6	16.5	14.1	16.5	8.3	4.4	0.7	0.7	1.2	2390	1830	121	106	.352	
7/12																														.319	
7/13																															
7/14						96	66	0	3	4	6.8	5.8	0.1	0.2	0.4	23.0	23.8	20.0	18.0	19.0	6.5	5.6	0.4	0.4	1.2	2350	2090	119	115	.279	
7/15						114	74	9	5	5	6.8	4.5	0.3	0.2	0.4	25.0	20.7	19.6	18.0	20.7	10.1	5.6	0.7	0.7	1.2	2330	2150	124	107	.318	
7/16	140	116	9.8	10.8	3.3	74	52	6	6	7	5.0	5.2	0.1	0.2	0.4	19.0	19.6	15.2	16.1	18.5	7.4	7.8	2.7	1.2	1.2	2260	2090	117	117	.355	
7/17	204	106	13.2	7.8	4.3	126	56	6	5	6	9.2	8.0	0.2	0.2	0.5	23.8	20.7	15.2	17.5	18.0	10.7	7.8	1.9	0.7	1.2	2240	2030	116	111	.316	
7/18	164	115	13.8	8.0	3.4	112	78	5	4	7	6.0	7.8	0.3	0.2	0.5	24.2	20.6	19.0	18.5	20.0	9.3	4.8	3.1	0.7	1.9	2440	1560	115	115	.314	
7/19																										1980	1910	116	105	.391	
7/20																														.386	
7/21						158	82	9	6	10						20.0	19.6	18.0	25.8	28.9	9.3	6.2	0.7	0.7	1.5	2760	1750	109	101	.264	
7/22	260	152	12.8	13.0	9.2	272	102	6	11	13	11.5	11.5	0.3	0.6	0.6	25.0	23.8	17.1	19.0	18.5	7.0	7.0	2.3	0.4	4.3	1840	2570			.315	
7/23	142	88	14.8	14.8	9.1	138	50	6	11	14	7.8	4.8	0.4	0.7	1.1	21.8	19.6	18.5	18.5	20.6	5.2	7.0	1.2	1.2	1.5	2240	2150	103	91	.334	.10
7/24	160	121	13.8	14.0	6.5	118	74	6	11	10	8.5	8.2	0.7	0.6	0.8	23.8	21.8	18.0	16.1	18.0	14.0	7.9	1.2	1.9	2.1	2160	2040	95	88	.345	
7/25	175	115	16.2	13.2	7.3	140	74	7	10	10	8.0	9.5	0.8	0.3	1.1	22.1	21.8	18.5	18.0	19.0	8.8	6.5	0.7	1.5	1.9					.322	
7/26																														.368	
7/27																														.321	.80
7/28						92	64	10	6	12	8.2	9.0	0.6	0.3	1.4	25.8	21.8	20.6	18.5	21.2	8.3	7.0	0.7	0.7	0.7	2720	1880			.320	.55
7/29						118	74	6	11	10	6.2	8.2	0.3	0.4	0.8	21.2	20.6	18.5	17.6	19.6	3.5*	6.6	0.3	1.2	0.7	1150	2340	121	86	.343	
7/30	180	118	12.0	6.6	11.5	138	102	10	4	8	9.5	10.0	0.3	0.2	0.4	21.2	21.8	17.6	15.2	16.2	7.6	4.7	1.5	1.9	1.5	2520	2290	103	87	.354	
7/31	169	125	6.8	10.0	4.1	114	84	7	5	9	9.5	10.1	0.2	0.2	0.6	26.4	23.0	15.7	18.0	17.6	9.3	6.1	1.2	1.9	1.5	2610	2300	92	89	.338	
AVE.	180	123	10.1	8.4	4.1	138	77	6.5	5.9	8.2	7.1	7.1	0.3	0.3	0.6	23.3	21.1	17.6	17.4	19.0	8.7	6.5	1.3	1.0	1.6	2490	1910	96	89	.345	
																										2450	1900	110	98	.328	

* Backwash water from water treatment plant might have caused fluctuation in raw and primary readings.

RS = Raw Sewage
PE = Primary Effluent
NI = North Tank
SI = South Tank
FE = Final Effluent

TABLE 4. Summary of Culver SBR Performance Data - August 1980

DATE	BOD_5 (mg/ℓ)					SUSPENDED SOLIDS (mg/ℓ)					PHOSPHORUS (mg/ℓ)					NH_3-N (mg/ℓ as N)					NO_x-N (mg/ℓ as N)					MLSS (mg/ℓ)		SVI (mℓ/g)		FLOW (MGD)	PPT (in)
	RS	PE	NI	ST	FE	RS	PE	NI	ST	FE	RS	PE	NI	ST	FE	RS	PE	NI	ST	FE	RS	PE	NI	ST	FE	NI	ST	NI	ST		
8/1						132	52	6	8	11																					
8/2																										2210	1850	96	92	.396	
8/3																														.338	
8/4						118	82	5	3	7	6.5	6.5	0.1	0.2	0.4	21.2	21.2	16.5	19.0	17.6	7.8	7.4	2.3	1.2	1.9					.233	
8/5						144	72	5	6	8	7.5	7.0	0.2	0.3	0.5	25.8	21.2	17.6	15.2	16.5	9.7	11.3	1.9	3.1	1.9	3430	1660	102	102	317	
8/6	154	100	14.6	10.2	-	114	64	9	3	8	5.5	7.5	0.3	0.1	0.5	21.2	22.3	15.2	22.3	21.2	14.6	10.3	1.9	3.5	2.7	2660	1580	98	98	321	.40
8/7						94	70	3	5	8	6.2	6.2	0.1	0.2	0.3	18.0	17.6	11.8	13.7	14.3	8.8	8.3	6.6	3.5	4.3	3110	1660	96	102	.294	.30
8/8	121	128	7.4	-	6.4	94	170	3	12	7	5.2	9.5	0.1	0.5	0.5	17.6	19.0	9.2	12.3	13.7	6.6	3.5	7.4	3.5	4.3	2840	1880	92	90	333	
8/9																										3170	1820	110	93	.34	.65
8/10								4																						400	.60
8/11						92	64	5	4	9	3.0	4.8	0.1	0.1	0.5	16.1	16.1	8.9	4.9	8.9	3.5	3.5	3.1	5.7	2.7	3390		124		421	
8/12						88	74	4	4	6	6.8	7.5	0.1	0.2	0.5	21.8	18.5	10.2	11.2	11.7	8.3	7.0	7.0	3.5	3.5	3030	1510	137	99	401	.70
8/13	162	112	8.2	14.2	7.0	124	64	3	5	9	6.2	7.8	0.1	0.2	2.0	17.6	16.1	3.9	12.3	8.0	7.4	7.0	11.3	1.5	3.8	3190	1700	122	106	340	
8/14*	88	82	12	12	12	72	80	19	27	30	4.5	5.2	2.9	2.9	2.9	19.9	12.7	12.9	15.7	15.2	2.8	2.4	1.2	1.5	1.5	3690	1780	108	107	369	1.05
8/15	88	58	9.4	7.0	11.9	92	52	3	4	4	4.2	3.2	0.1	0.2	0.3	17.1	16.6	6.8	6.4	9.7	10.7	6.5	11.3	9.3	7.8	2960	1950	132	108	353	.50
8/16																					3.5	6.0	9.8	7.8	8.3	3210	2300	125	87	379	
8/17																														341	.70
8/18						44	40	3	4	9	18	13.5	0.2	0.2	0.5	15.0	13.0	.05	5.9	3.3	3.5	6.0	9.8	7.8	8.3	3060	1800			364	.20
8/19†	113	88	6.6	15.8	15.8	82	66	3	8	9	3.2	4.2	0.2	0.5	0.4	14.2	13.4	1.5	7.8	5.3	3480	1740	103	103	387	.05
8/20	122	105	8.0	15.8	15.5	86	70	3	3	10	4.8	4.5	0.2	0.3	0.6	13.8	15.0	0.7	8.5	7.7	16.3	9.3	11.3	3.5	6.5		2720		107	376	.30
8/21	126	142	15.6	15.6	12.6	94	84	6	15	23	5.5	5.2	0.4	1.2	1.5	15.9	15.0	>45	12.8	9.2	5.7	4.7	11.8	3.8	4.3	2930	2420	97	97	367	
8/22	105	66	8.6	16.8	4.3	124	112	3	9	11	4.2	4.5	0.2	0.3	0.7	7.0	8.0	1.1	13.4	14.7	7.8	6.0	1.1	1.1	1.1	3070	2720	108		346	
8/23																					5.2	3.8	7.8	3.5	3.8	2940	3010	92	101	384	
8/24																														371	
8/25						98	64	6	8	12	5.8	5.8	0.5	0.3	0.6	18.2	14.7	1.5	1.5	2.4	6.6	4.1	6.6	11.8	7.4	1860	2500	93	100	.254	
8/26						104	46	5	7	11	5.0	5.8	0.3	0.2	0.5	17.8	16.8	0.7	0.9	2.9	11.8	8.3	6.6	10.8	7.0	2530	2690	91	89	.311	
8/27‡						92	52	7	41	18																2550	2480	110	101	.323	
8/28	131	106	10.4	13.8	14.9	118	60	3	8	15	6.0	7.2	0.4	0.4	0.7	17.2	15.4	0.4	2.3	2.7	4.7	3.9	5.4	6.1	7.4	1410	1720	85	110	.313	
8/29	169	125	7.2	16.4	13.5	128	74	4	9	18	7.8	7.0	0.5	0.5	1.0	21.6	16.8	1.1	3.8	3.3	7.0	7.0	6.6	6.1	5.2	1580	3650	104	99	.341	
8/30																										1630	1150	104	133	.350	
8/31																														.450	2.45
AVE.	125	101	9.8	13.7	11.4	107	72	5.1	9.2	11.6	6.1	6.5	0.3	0.4	0.7	17.7	16.4	6.6#	10.0	9.9	7.9	6.6	6.5	4.8	4.7	1770				.390	.3
																										2840	2270	106	101	.350	

* The microprocessor was inoperative for 12 hrs. Aeration tanks were in idle for those 12 hours, thus the test results were affected.

† South Tank only reactor. North Tank MLSS removed.

‡ Pumps and blowers for South Tank were on manual from 8:00 p.m. 8/26 to 6:00 a.m. 8/27.

Does not include data of 8/21.

RS = Raw Sewage
PE = Primary Effluent
NI = North Tank
ST = South Tank
FE = Final Effluent

TABLE 5. Summary of Culver SBR Performance Data - September 1980

DATE	BOD_5 (mg/ℓ)					SUSPENDED SOLIDS (mg/ℓ)					PHOSPHORUS (mg/ℓ)					NH_3-N (mg/ℓ as N)					NO_x-N (mg/ℓ as N)					MLSS (mg/ℓ)		SVI (mℓ/g)		FLOW (MGD)	FFT (in)
	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	NT	ST	NT	ST		
9/1																										2060				.419	
9/2						88	120	15	2	19	4.0	6.2	0.6	0.2	1.1	12.7	12.7	7.4	6.4	7.9	7.4	1.5	0.7	0.7	1.9	2030	3030	123	135	.453	0.95
9/3						108	82			19																				.357	
9/4*	139	112	16.4	16.4	11.8	100	96	5	10	18	4.2	6.0	0.3	0.5	1.2	20.3	16.8	8.8	10.4	10.8	6.6	4.3	7.4	1.2	3.5	1820	3880	93	191	.420	0.15
9/5†	92	75	12.8	9.6	12.5	74	56	6	5	19	3.2	5.0	0.3	0.2	0.9	15.9	14.2	7.7	4.2	6.2	5.2	3.1	3.1	4.3	4.0	2330	3280	118	146	.400	
9/6																														.323	
9/7																														.403	
9/8						114	74			8	7.8	4.8			0.4	19.3	16.8			1.3	6.1	5.6			5.2		2370		101	.351	
9/9	135	114			6.4	98	62			8	4.8	4.2			0.4	21.6	18.3			1.7	6.6	6.1			4.3	3440	2540	96	106	.302	.1
9/10	215	110	10	11.2	2.7	208	66	4	4	14	7.0	5.2	0.4	0.2	0.7	22.2	17.3	0.8	5.8	3.7	7.4	4.3	7.8	5.6	6.1	3310	2850	112	105	.338	
9/11	182	170	10	16.6	15.3	160	112	9	5	31	8.8	7.0	0.3	0.5	1.7	22.8	21.0	2.2	12.7	10.1	11.8	8.7	7.4	5.2	3.8	3450	2280	100	127	.336	
9/12	168	172	9.8	10.8	0.7	122	116	7	4	17	8.5	9.5	0.2	0.2	0.7	22.8	21.0	0.5	4.7	6.2	7.8	7.0	6.1	6.1	5.6	3280	2950	91	115	.337	.3
9/13																														.339	
9/14																										3160	2380	139	126	.300	
9/15						106	78	5	6	17	9.5	8.0	0.2	0.3	0.6	21.0	21.0	0.2	7.8	7.0	7.8	5.2	6.1	3.1	3.5	2820	2870	99	136	.334	.10
9/16						134	94	9	6	16	8.0	7.2	.5	.3	.7	24.1	21.6	0.5	6.2	2.8	12.8	10.3	6.1	5.3	8.3	3180	2150	82	112	.452	1.5
9/17	74	44	11	17.4	2.2	84	84	15	10	20	2.2	4.0	.7	.7	1.1	15.4	13.8	0.4	6.7	7.2	4.3	5.2	7.8	4.7	6.1	2920	2510	96	122	.382	.05
9/18	131	115	13	16.2	1.9	102	78	9	6	13	4.8	7.2	.6	.6	.9	18.3	18.8	4.7	7.7	5.7	6.1	3.8	5.6	3.8	5.2	2890	2100	86	107	.362	
9/19	166	146	16.8	16.8	1.3	88	68	9	9	15	4.8	6.2	0.4	0.4	0.8	19.3	22.2	3.3	7.7	6.7	7.8	8.3	4.7	6.6	6.1	2990	2060	87	102	.368	
9/20																														.364	
9/21																														.244	
9/22						104	94	13	9	17	9.5	8.5	0.3	0.2	0.5	22.8	23.5	0.1	11.2	8.3	8.3	6.9	6.6	3.5	5.2	3390	1580	122	133	.324	.75
9/23						148	94	10	12	14						22.8	21.6	5.3	7.2	6.7	8.7	5.3	7.4	4.7	7.1	2490	2010	88	112	.365	
9/24	128	136	5.8	13.4	3.1	124	92	9	8	11	5.8	4.8	0.3	0.2	0.5	20.4	21.0	6.3	7.2	7.8	7.4	14.8	8.3	2.3	3.1	2820	1650	92	133	.340	.10
9/25	118	132	5.0	12.2	0.5	124	96	8	5	12	6.0	5.0	0.3	0.2	0.6	7.8	7.3	2.4	9.9	5.7	7.1	7.4	5.3	1.5	4.7	2980	1850	138	124	.352	.05
9/26						156	70	5	6	7	7.2	6.0	0.3	0.2	0.4	20.4	21.0	2.9	10.5	7.0	8.3	6.0	7.1	2.7	4.3	2820	1950		118	.386	
9/27																										2610	2030	164	128	.309	
9/28																										2650	2180	208	151	.302	
9/29						212	110	7	7	9	8.5	8.0	0.8	0.2	0.6	28.7	25.4	24.1	11.5	9.2	8.3	8.8	6.0	6.0	5.6	3060	2320	219	142	.327	
9/30																										2550	2310	212	234	.305	
AVG.	141	121	11.1	14.1	5.3	123	87	8	7	14	6.4	6.3	0.4	0.3	0.7	19.9	18.7	4.6	8.1	6.4	7.7	6.5	6.1	4.0	4.9	2828	2400	122	131	.353	

* Plant in batch system during day and continuous flow during the night.
† Started continuous flow 24 hrs/day due to microprocessor problem until 9/9/80.

RS = Raw Sewage
PE = Primary Effluent
NT = North Tank
ST = South Tank
FE = Final Effluent

TABLE 6. Summary of Culver SBR Performance Data - October 1980

DATE	BOD_5 (mg/ℓ)					SUSPENDED SOLIDS (mg/ℓ)					PHOSPHORUS (mg/ℓ)					NH_3-N (mg/ℓ as N)					NO_x-N (mg/ℓ as N)					MLSS (mg/ℓ)		SVI (ml/gr)		FLOW (MGD)	PPT (in)
	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	NT	ST	NT	ST		
10/1	190	180	7.4	8.8	2.2	354	192	5	5	9	8.5	11.5	.5	.4	.7	21.6	21.0	4.6	17.8	11.9	4.7	6.0	3.9	1.4	2.7	2790	1840	186	126	.322	.3
10/2	199	140	8.4	7.4	1.4	284	112	7	8	9	10.5	10.8	1.3	.4	1.0	23.5	21.0	12.2	15.9	14.2	5.7	6.0	2.7	1.9	3.0	1990	2180	151	183	.312	
10/3	192	146	6.8	10.4	11.4	208	84	4	7	10	8.0	8.8	1.1	1.6	1.2	22.8	23.5	13.4	19.9	16.8	7.0	7.0	2.3	0.4	1.1	2450	1720	208	128	.367	.15
10/4																														.308	.35
10/5																										1980	1800	146	155	.306	
10/6						120	70	7	8	8	6.0	8.8	0.1	0.6	1.4	24.8	22.8	14.7	18.8	17.8	7.4	4.7	1.1	0.7	0.7	2140	1910	154	152	.318	
10/7						112	60	8	8	11	11.0	8.8	0.2	0.5	0.9	22.8	23.5	16.0	21.0	18.2	9.8	8.8	1.5	0.7	1.5	2400	1900	238	132	.319	
10/8						186	56	6	14	12	8.5	7.0	0.2	0.5	1.5	19.3	22.1	20.3	18.2	17.8	6.5	8.3	1.1	0.4	1.5	2630		270		.297	
10/9	199	139	11.6	11.4	2.8	204	64	8	10	11	15.2	8.5	0.2	1.0	1.3	22.8	19.9	11.2	18.2	16.8	10.3	9.3	10.7	0.7	1.5	2640	2150	258	186	.307	
10/10	137	120	9.2	8.0	1.1	158	80	5	12	10	10.0	7.0	0.4	0.4	0.6	21.5	19.9	13.4	18.2	17.3	9.8	10.7	3.0	0.3	1.5	2860	2010	255	134	.331	
10/11																														.306	
10/12																										2770	2340	176	179	.288	
10/13						136	72	6	5	3	6.7	9.2	0.2	0.3	0.7											2720	1820	151	164	.322	0.4
10/14						118	84	9	9	14	12.5	10	0.3	0.3	1.3											2600	1990	138	156	.296	0.05
10/15	173	139	10	7	3	184	66	-	10	13	13.0	11	0.2	0.4	1.0											2710	2050	144	156	.225	0.05
10/16	133	114	11	-	12	108	56	8	185	14			0.3	1.4	0.8											2570	2340	194	171	.270	0.65
10/17	185	145	14	14	2	246	126	9	10	12																3110	2100	151	176	.380	0.20
10/18																															
10/19																										2720	2300	158	170	.582	
10/20						158	76	6	6	11	6.1	6.0	0.3	0.3	0.7							8.5	1.0	1.4		2700	2100	152	167	.321	
10/21						238	74	8	12	17																2330	2470	137	146	.300	
10/22	152	139	9	8	4	114	68	7	12	10	7.0	7.2	0.3	0.4	0.7											2540		146		.261	
10/23	166	102	11	8	2	180	68	8	9	6	9.5	10.8	0.1	0.4	0.5											2400	2220	138	135	.319	
10/24	182	119	11	6	2	142	64	11	9	5																2880	2030	148	133	.380	
10/25																														.304	0.40
10/26																										2960	2120	152	141	.305	
10/27						116	64	11	9	5	7.5	7.5	0.2	0.9	0.9	26.2	24.1	20.0	20.3	22.2	7.0	7.0	1.0	0.7	0.3	2880	2330	177	135	.370	0.54
10/28						102	66	5	13	16	5.2	5.0	0.2	0.3	0.8	21.0	21.5	15.9	20.0	20.3	7.0	5.6	1.0	0.3	1.5	3070	2230	264	166	.336	
10/29						144	50	56	4	22	7.0	4.8	1.4	0.2	1.0											2360	2450	178	147	.321	
10/30	116	91	15	7	5	166	46	15	6	28	7.8	4.0	0.4	0.2	1.2	20.3	19.3	19.3	19.3	19.3	8.0	9.4	0.7	1.0	1.0	2070	2020	164	154	.322	
10/31	162	126	9	9	3	120	88	12	11	16						24.1	24.1	21.5	22.2	21.5	12.8	14.6	2.3	0.7	1.5	2190	1890	192	148	.325	
AVG.	168	131	10	9	4	169	78	10	9 *	12	8.9	8.2	0.4	0.6	1.0	22.6	21.9	15.1	19.2	17.8	8.0	8.1	2.5	0.8	1.5	2570	2090	179	151	324	

* Does not include data of 10/16

RS = Raw Sewage
PE = Primary Effluent
NT = North Tank
ST = South Tank
FE = Final Effluent

TABLE 7. Summary of Culver SBR Performance Data - November 1980

DATE	BOD_5 (mg/ℓ)					SUSPENDED SOLIDS (mg/ℓ)					PHOSPHORUS (mg/ℓ)					NH_3-N (mg/ℓ as N)					NO_x-N (mg/ℓ as N)					MLSS (mg/ℓ)		SVI (mℓ/gr)		FLOW (MGD)	PTI (in)
	RS	PE	NI	SI	FE	RS	PE	NI	SI	FE	RS	PE	NI	SI	FE	RS	PE	NI	SI	FE	RS	PE	NI	SI	FE	NI	SI	NI	SI		
11/1																														.277	
11/2																										2290	2000	266	165	.288	
11/3						100	72	5	13	14	7.0	5.0	0.2	0.6	0.6	15.5	18.8	15.5	18.8	17.3	11.7	11.7	0.3	0.7	1.9	2440	1970	205	127	.311	
11/4						164	60	2	10	13	6.2	5.5	0.3	0.5	0.6	23.5	22.8	17.8	17.3	17.8	19.9	14.0	1.9	1.9	2.3	2430	2160	189	120	.308	
11/5	128	136	4	11	11	82	66	7	12	11	5.2	5.0	0.2	0.4	0.5	21.0	21.5	18.8	19.3	20.0	6.5	9.3	1.2	0.3	0.3	2410	2150	328	135	.293	
11/6	188	118	10	6	2	144	68	10	10	13	11.8	7.0	0.3	0.4	0.6	24.1	21.5	17.8	17.8	18.3	7.4	7.8	0.3	0.7	1.9	2620	1980	315	126	.309	
11/7	225	134	10	8	2	218	58	5	6	12	11.8	8.0	0.4	0.5	0.7	24.8	22.8	20.3	21.0	21.5	11.7	7.8	0.3	0.7	1.9	2270	2310	253	134	.325	
11/8																														.294	
11/9																										2290	2120	214	151	.277	
11/10						162	92	7	6	13	7.0	5.8	0.3	0.1	0.9	30.3	25.4	20.3	21.6	20.3	8.8	4.7	0.3	0.7	1.9	2390	2110	146	132	.302	
11/11						136	66	10	11	14	7.5	7.8	0.4	0.4	0.6	28.7	29.5	24.8	24.8	24.8	7.8	7.8	0.7	0.7	1.9	2250	2250	164	133	.293	
11/12	225	148	10	5	2.3	200	60	1	6	11	6.2	6.2	0.3	0.4	0.5	22.8	24.0	19.3	21.0	21.0	8.3	9.8	1.2	4.0	1.5	2340	2250	250	124	.280	
11/13	165	169	12	7	3	162	76	6	5	13	6.5	6.2	0.5	0.4	0.7	21.5	24.0	20.3	21.5	21.0	9.8	11.8	1.5	3.0	2.3	2390	2350	167	172	.320	.45
11/14						122	60	7	6	11	7.2	5.0	0.3	0.2	0.6	22.2	23.5	18.3	22.2	21.5	8.3	11.1	1.9	0.7	1.9	2560	2380	195	134	.318	.10
11/15																														.275	
11/16																										2810				.288	
11/17						156	64	5	7	14																2710	1990	299	138	.331	
11/18	182	195	10	5	2	122	122	15	6	11	10.8	14.8	0.4	0.4	0.7	22.2	24.8	20.0	21.5	20.3	6.4	3.9	0.5	0.3	0.7	2290	2210	175	127	.309	
11/19						240	94	8	9	13	8.7				0.9											2500	2390	132	95	.261	
11/20	171	146	13	6	2	138	66	5	11	12	10.8	7.5	0.3	0.3	0.5						3.7	4.4	0.3	0.3	0.8	2540	1970	158	140	.310	
11/21	178	154	9	10	1	118	64	4	6	10	7.5	8.5	0.2	0.4	0.6	20.3	24.1	21.7	22.2	23.5	3.7	3.6	0.1	0.1	0.8	2080	1830	135	153	.317	
11/22																														.288	.15
11/23																										2250	1790	142	151	.318	.20
11/24						86	54	3	2	11	8.2	7.8	0.5	0.3	0.9	22.8	22.8	20.0	20.0	21.0	8.3	4.1	0.6	0.3	0.6	2540	2100	161	152	.315	.10
11/25						130	54	3	6	10	7.0	6.5	0.2	0.6	1.4	22.2	22.8	18.8	22.0	21.6	3.0	3.7	0.1	0.1	0.8	2100	2290	176	135	.334	
11/26	266	173	10	17	3	158	72	6	7	14	5.8	7.2	0.3	0.8	1.2	22.2	22.2	19.3	21.0	21.0	4.6	3.9	0.1	0.8	0.8	2120	2180	179	167	.337	0.25
11/27																										2140		149		.318	0.50
11/28	95	86	5	5	4	122	68	3	4	8	6.5	6.9			0.2						3.6	3.2			0.8	2230	2390	166	130	.399	0.10
11/29																														.315	0.10
11/30																														.310	
AVE.	183	146	9	8	3	145	70	6	8	13	7.9	7.1	0.3	0.4	0.7	21	23	20	21	21	7.9	7.2	0.7	1.0	1.4	2386	2144	198	139	.310	

RS = Raw Sewage
PE = Primary Effluent
NI = North Tank
SI = South Tank
FE = Final Effluent

TABLE 8. Summary of Culver SBR Performance Data - December 1980

DATE	BOD_5 (mg/ℓ)					SUSPENDED SOLIDS (mg/ℓ)					PHOSPHORUS (mg/ℓ)					NH_3-N (mg/ℓ as N)					NO_x-N (mg/ℓ as N)					MLSS (mg/ℓ)		SVI (mℓ/gm)		FLOW (MGD)	FPI (in)
	RS	PE	NI	SI	FE	RS	PE	NI	SI	FE	RS	PE	NI	SI	FE	RS	PE	NI	SI	FE	RS	PE	NI	SI	FE	NI	SI	NI	SI		
12/1						84	50	4	7	12																					
12/2	153	124	6	8	9	86	54	3	5	10	11.8	8.0	0.4	0.5	0.7	23	24	22	24	23	3.7	4.4	0.3	0.3	0.8	2250	2020	253	186	0.380	.70
12/3						38	26	8	6	10																2200	2380	277	210	0.369	.10
12/4						146	80	3	6	13	8.0	6.7	0.4	1.2	1.0	26	22	24	-	22	4.0	3.7	0.4	-	0.6	2370				.363	
12/5						110	70	6	3	12	8.4	6.4	0.4	0.4	-	23	23	20	21	20	3.7	3.5	0.3	0.6	0.6					.349	.10
12/6																19	20	20	20	21	4.4	3.5	0.1	0.3	0.3	2690	2300			.381	.05
12/7																														.308	
12/8	149	115	8	16	16	90	64	6	9	14	5.0	4.5	0.5	0.5	0.6	22	21	17	19	20	1.1	2.0	0.2	0.4	0.5	2560	2490	261	168	.384	.85
12/9	163	71	3	4	-	134	60	1	15	14	6.2	5.7	0.5	1.0	1.5	14	14	17	17	19	5.4	4.0	0.5	0.6	0.3	2580	2370	221	143	.455	.80
12/10	175	105	7	6	1	142	74	2	4	16	8.8	7.8	0.4	0.5	1.1	24	22	18	17	16	3.5	2.5	0.5	0.5	0.6	2390	2370	167	131	.412	
12/11	191	104	9	9	1	159	53	3	6	11	8.7	7.5	0.4	0.5	0.8	18	17	15	15	15	2.5	1.7	0.2	0.3	0.6	2360	2470	174	134	.374	.10
12/12						117	42	1	2	14	6.7	6.0	0.5	0.6	1.4	17	15	13	13	14	3.5	2.8	-	-	0.6	2570	2600	206	131	.381	.05
12/13						126	69	4	5	16																2310	2360	143	144	.392	
12/14																														.349	
12/15						115	55	7	27	18	9.8	7.5	0.6	1.4	1.2	24	24	18	19	17	6.3	3.8	0.5	0.6	1.3	2570	2550	152	161	.353	
12/16	207	100	8	13	11	109	65	6	10	8	2.3	7.5	1.6	0.6	0.8	19	21	17	18	18	2.8	2.4	0.6	0.5	0.5	2980	2370	136	143	.376	
12/17	241	145	16	18	18	132	52	6	7	10	6.5	5.9	0.5	0.6	0.6	17	18	18	18	20	1.8	1.8	0.5	0.6	0.6	3380	1900	109	153	.364	
12/18	248	214	17	15	7	228	83	11	14	14						23	23	18	21	22	3.7	4.5	1.5	1.3	1.0	2870	2580	129	132	.323	
12/19						148	110	11	11	21	11.3	9.2	1.3	0.8	3.2	22	21	23	20	21	4.6	2.7	0.3	0.4	0.5		2710		122	.337	
12/20						66	72	8	10	18																2420	2650	120	117	.346	
12/21																										2440	2380	127	118	.290	
12/22						143	95	1	13	13	7.8	5.0	0.4	0.7	0.7	24	17	14	14	20	2.0	1.5	0.3	0.4	0.8	2150	2630	125	124	.269	
12/23						110	80	9	8	12	7.3	5.8	0.5	0.4	0.6	22	17	14	14	15	4.6	4.5	0.5	1.3	0.8	2170	2560	129	117	.323	
12/24	128	102	14	14	2	96	69	13	8	14	4.2	5.6	0.6	0.4	0.7	17	15	14	15	16	5.4	6.4	1.8	0.8	1.2	2540	2220	114	117	.319	.35
12/25						126	61	10	10	14	4.4	3.1	1.6	0.4	0.5	14	14	14	12	13	3.5	3.2	0.5	0.5	0.7	2160	2520	130	111	.320	.10
12/26																										2550	2400	137	129	.280	
12/27						112	67	5	9	10	4.8	4.0	0.3	0.3	0.6	15	15	16	16	16	1.4	0.6	0.0	0.0	0.5	2150	2460	126	118	.323	
12/28																														.294	
12/29	153	123	10	12	3	119	95	11	9	17	4.9	5.2	0.4	0.8	0.7	17	17	15	16	17	3.5	3.2	0.5	0.5	0.7	1890	2390	132	117	.268	.40
12/30	86	79	8	6	1	79	69	8	8	14	4.5	3.5	0.2	0.3	0.5	15	16	15	15	15	2.9	2.9	0.0	0.6	0.5	2230	2450	121	118	.327	.20
12/31	62	69	12	6	0.5	48	49	13	8	8	2.8	3.3	0.5	0.3	0.4	15	14	16	18	16	2.5	6.3	0.4	0.2	0.6	2090	2140	129	126	.290	
AVE.	163	113	10	11	6	119	69	7	9	14	7.1	5.9	0.6	0.6	0.9	19	19	17	17	18	3.6	3.3	0.5	0.5	0.7	2380	2480	122	101	.330	.20
																										2431	2413	150	135	.345	

RS = Raw Sewage
PE = Primary Effluent
NI = North Tank
SI = South Tank
FE = Final Effluent

TABLE 9. Summary of Culver SBR Performance Data - January 1981

DATE	BOD_5 (mg/ℓ)					SUSPENDED SOLIDS (mg/ℓ)					PHOSPHORUS (mg/ℓ)					NH_3-N (mg/ℓ as N)					NO_x-N (mg/ℓ as N)					MLSS (mg/ℓ)		SVI (mℓ/g)		FLOW (MGD)	PPT (in)
	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	NT	ST	NT	ST		
1/1																										2160		125		.322	
2	135	90	6	7	1	117	59	7	3	9	4.3	3.3	0.2	0.2	0.4	21	17	15	15	15	6.5	4.2	0.5	0.4	1.0	1980	2230	141	125	.332	
3																														.306	1 S
4																										2010	2120	124	118	.295	
5	116	61	7	7	0	148	77	5	9	13	6.2	3.5	0.0	0.2	0.6	22	22	20	19	22	1.3	1.1	0.1	0.1	0.6	1900	1980	132	116	.417	
6	98	90	13	13	2	91	64	4	8	11	5.7	5.9	0.4	0.4	0.6	19	20	17	20	19	6.0	4.3	0.8	0.3	0.9	2340	2260	115	111	.326	2 S
7	190	151	10	12	2	143	76	7	9	16	10.0	7.2	0.4	0.4	0.7	21	20	17	20	20	5.2	4.0	0.7	0.6	0.7	2070	2440	98	107	.329	3 S
8	178	103	13	13	8	83	69	14	7	13	5.0	5.2	0.6	0.6	0.8	21	18	18	18	19	7.0	7.0	0.5	0.7	0.7	2250	2500	111	104	.363	
9						160	82	38	40	23																	2550		110	.367	
10																														.322	
11																										2140	2760	112	105	.312	
12	155	-	3	2	4	150	78	38	11	16	6.4	5.6	1.5	0.6	0.8	21	23	18	17	22	6.2	2.5	1.3	1.0		2040	2760	118	101	.370	
13	188	154	13	4	3	222	75	8	18	18	5.9	5.1	0.1	0.7	0.9	22	22	20	20	24	7.8	8.0	1.2	0.8	0.9	2120	2620	113	103	.332	
14	197	177	10	10	5	102	95	7	10	15	7.3	6.9	0.4	0.7	0.8	17	22	22	19	21	4.4	6.7	0.8	0.4	0.6	2190	2580	119	105	.309	
15	226	205				141	96	11	10	18	5.9	5.1	0.8	0.5	0.8	24	21	21	22	22	7.3	8.8	1.4	0.5	0.7	1990	2550	121	102	.349	
16						84	98	11	13	41																1560	2560	115	105	.392	.20
17																														.362	
18	145	127	5	9	0	120	70	3	5	12	5.7	4.6	0.3	0.3	0.7	25	21	20	20	22	2.5	2.7	0.3	0.2	0.3	1810	2550	122	123	.336	
19	169	158	10	11	0	95	68	7	9	11			0.3	0.3	0.8	22	21	18	19	19	3.2	3.7	0.0	0.1	0.1	1950	2510	123	104	.346	
20	159	165	11	9	0	98	78	5	2	15						25	23	18	19	19	2.9	3.3	0.5	0.4	1.1	2230	2170	121	106	.339	
21	119	115		11	2	127	50		8	10																	2240		112	.343	
22						113	77	5	6	12						21	22	19	21	19	2.5	3.5	0.3	0.5	1.0	2190	1880	128	112	.364	
23						129	69	4	8	13																2290	1970	122	112	.374	
24																														.354	
25																										2200	1990	132	111	.366	
26						102	71	3	6	11																2210	2400	132	90	.403	
27						119	51	4	7	12																2320	2180	129	110	.364	
28	188	159	9	10	2	113	91	6	8	11						23	21	21	18	20	3.6	6.0	0.5	0.3	0.7	2290	1930	140	114	.349	
29	128	119	9	11	5	116	85	6	9	14																2340	2030	137	113	.341	
30		122	13	17	6	155	81	8	12	19																2320	2060	211	117	.388	
31																														.336	
AVE.	159	133	9	10	3	124	75	10	10	15	6.2	5.3	0.5	0.4	0.7	22	21	19	19	20	4.7	4.7	0.6	0.5	0.7	2120	2310	127	109	.349	

RS = Raw Sewage
PE = Primary Effluent
NT = North Tank
ST = South Tank
FE = Final Effluent
S = Inches of snow

TABLE 10. Summary of Culver SBR Performance Data - February 1981

DATE	BOD_5 (mg/ℓ)					SUSPENDED SOLIDS (mg/ℓ)					PHOSPHORUS (mg/ℓ)					NH_3-N (mg/ℓ as N)					NO_x-N (mg/ℓ as N)					MLSS (mg/ℓ)		SVI (mℓ/g)		FLOW (MGD)	PPT (in)
	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	NT	ST	NT	ST		
2/1						140	97	8	10	14						16	19	19	20	21	1.3	1.7	0.0	0.1	0.4	2240	2740	344	133	.403	0.30
2						116	68	13	10	26	6.2	5.5	0.8	0.3	0.8	20	18	15	15	16	2.0	2.4	0.1	0.3	0.3	2240	2500	143	116	.369	
3						116	84	5	5	20	6.8	4.5	0.1	0.3	0.4	27	24	24	20	22	6.0	4.7	0.4	0.9	0.6	2280	2540	149	102	.348	
4						141	63	6	10	18	5.7	4.2	0.2	0.3	0.6	16	18	21	20	21	5.0	3.7	0.5	0.3	0.7	2620	2550	160	110	.349	
5	164	107	7	10	4	135	78	8	11	22	6.6	5.0	0.5	0.4	0.7	21	20	19	19	21	2.8	2.0	0.5	0.5	0.5	3200	2280	266	110	.340	
6						169	71	7	17	17	5.3	5.0	0.2	0.7	0.7											2090	2530	148	107	.351	0.10
7																														.260	
8																										2420	2410	136	118	.311	
9	180	151	14	17	8	90	75	10	16	24																2330	2460	159	114	.346	
10	111	132	15	14	5	98	83	11	17	20	6.0	5.9	0.2	0.2	0.4	22	23	24	21	22	2.1	2.5	0.0	0.0	0.0	2280	2100	136	110	.450	1.60
11						90	61	7	10	48	3.6	3.3	0.7	0.5	1.7	14	14	14	12	14	1.2	0.8	0.2	0.3	0.3	2240	2390	138	113	.310	
12	135	133	7	10	9	89	94	5	9		5.6	5.1	0.2	0.7	1.0	18	21	14	15	16	3.0	2.6	0.0	0.0	0.0	2000	2380	135	113	.341	
13						113	50	8	9	26																2260	1920	128	115	.364	
14																														.360	
15																														.463	
16	83					112	90	10	19	40																2530	2400	134	123	.513	0.01
17						46	42	2	39	26	2.1	2.2	0.4	0.9	1.4	8	7	10	12	11	0.8	0.8	0.8	0.7	0.8	2650	2220	102	95	.496	0.01
18						124	75	11	28	43	2.9	2.2	0.4	0.7	1.4	9	8	9	12	11	1.2	0.9	0.8	0.9	0.8	2390	2280	117	83	.472	
19	163	118	18	21	8	152	64	18	18	30	5.8	4.6	0.7	0.6	1.0	16	16	12	13	15	2.0	2.6	0.6	0.7	0.5	2590	2270	108	68	.433	0.05
20						65	55	10	17	23	3.2	3.3	0.5	0.7	0.8	14	15	12	15	13	0.6	1.5	0.5	0.5	0.6	2490	1670	104	78	.432	0.05
21																														.393	
22																												92	71	.367	.15
23						132	80	14	4	20	6.5	5.3	0.7	0.4	0.7	26	23	16	14	14	2.0	2.6	0.3	0.5	0.3	1910	1780	99	79	.429	.15
24	210	180	13	16	8	83	59	9	10	19	5.5	3.7	0.6	0.8	0.7	18	17	16	16	16	3.0	2.0	0.6	0.3	0.3	2260	2150	93	65	.412	
25	211	151	17	22	5	205	52	12	15	22	6.1	4.3	0.8	0.8	0.8	16	16	16	17	16	2.4	3.4	0.8	0.5	0.6	2340	2650	94	72	.404	
26						182	68	10	3	19	6.2	3.6	0.6	0.8	0.7	14	17	18	18	17	4.0	6.0	1.0	2.7	1.3	2320	2880	91	71	.390	
27	154	108	9	16	5	88	60	9	6	12																2450	2570	102	78	.424	.20
28																														.374	
AVE.	157	135	13	16	7	118	70	9	13	24	5.3	4.2	0.5	0.6	0.9	17	17	16	16	17	2.5	2.5	0.4	0.6	0.5	2370	2335	138	97	.389	

RS = Raw Sewage
PE = Primary Effluent
NT = North Tank
ST = South Tank
FE = Final Effluent

TABLE 11. Summary of Culver SBR Performance Data - March 1981

DATE	BOD_5 (mg/ℓ)					SUSPENDED SOLIDS (mg/ℓ)					PHOSPHORUS (mg/ℓ)					NH_3-N (mg/ℓ as N)					NO_x-N (mg/ℓ as N)					MLSS (mg/ℓ)		SVI (mℓ/g)		FLOW (MGD)	PPT (in)
	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	NT	ST	NT	ST		
3/1	160	104	9	9	5	97	82	10	10	19	4.3	4.2	0.3	0.3	0.7	20	20	20	16	18	1.8	1.5	0.0	0.1	0.3	2900	2600	103	83	.348	
2						144	74	7	10	25	6.2	4.3	0.4	0.6	1.6	22	19	20	18	18	1.3	3.0	0.8	0.2	0.5	2970	2470	104	89	.390	
3	174	130	9	9	7	168	64	8	9	19	6.6	8.3	0.5	0.3	1.1	21	21	20	19	19	4.1	4.7	0.5	1.6	0.6	2660	2620	102	88	.369	
4	177	183	10	11	10	98	99	4	14	12	6.7	5.8	0.2	0.4	0.6	22	24	22	21	21	3.2	3.5	0.6	0.1	0.8	2790	2400	107	83	.375	.30
5	186	132	7	9	6	187	85	7	12	15	7.9	7.8	0.2	0.3	0.3	16	19	17	15	18	7.8	1.3	0.1	0.2	0.1	2800	2250	107	89	.381	
6	204	151	9	12	7	199	79	8	11	21	11.4	7.2	0.3	0.4	1.0	20	20	19	16	17	1.4	2.0	0.1	0.2	0.3	2410	2450	100	86	.392	
7																														.362	
8						118	88	15	5	9	5.9	5.6	0.5	0.2	0.4	21	20	18	17	18	2.6	2.5	0.3	0.3	0.3	2260	2370	99	89	.330	
9						138	75	9	10	27	6.2	5.8	0.3	0.5	1.4	25	21	16	18	17	1.8	2.0	0.5	0.1	0.5	2460	2020	106	94	.385	
10	218	160	8	12	6	142	61	6	10	24																2570	2370	105	93	.352	
11						128	98	7	14	22																2680	2340	108	98	.354	.40
12	147	125	8	9	5	112	70	7	9	15	5.7	4.7	0.7	0.5	0.8	21	19	21	21	21	2.6	3.0	1.0	0.6	0.5	2940	1750	109	94	.355	
13						144	76	4	11	14	6.3	4.4	0.6	0.6	0.5	21	19	20	19	19	2.3	3.5	1.2	0.3	0.3	2630	1600	116	94	.384	
14																														.331	
15						136	132	9	13	16	5.7	5.2	0.4	0.5	0.7	21	20	18	17	16	1.3	1.3	0	0.1	0.3	2710	2000	125	105	.320	
16						60	132	5	1	26	5.0	5.5	0.2	0.3	0.9	17	17	16	16	16	4.5	2.4	0.1	0.6	0.2	2480	2010	109	104	.347	
17	245	130	11	10	5	192	65	6	11	17	4.6	3.1	0.5	0.6	0.7	24	21	19	17	18	1.8	1.2	0.2	0.5	0.5	2310	2130	126	108	.328	
18	200	124	9	8	4	226	90	11	6	30	6.2	5.0	0.4	0.6	0.8	23	21	21	19	20	2.0	1.8	0.3	1.0	0.5	2180	2090	124	105	.348	.10
19	267	190	10	11	7	182	116	10	15	18	9.7	5.5	0.5	0.6	0.9											2550	2140	114	103	.335	.10
20						220	88	10	11	13	6.1	4.0	0.3	0.5	0.8											2270	2000	132	110	.358	
21																														.312	
22																															
23	118	118	5	5	2	94	90	5	6	12	6.9	5.8	0.4	0.3	0.6											2150	1810	149	122	.263	
24	71	81	5	5	2	74	60	4	6	9	6.0	4.7	0.3	0.4	0.3	12	14	18	16	17	1.7	3.3	0.5	0.6	0.5	2180	1450	156	117	.299	
25	49	101	7	8	3	76	40	5	10	13	4.8	4.8	0.3	0.5	0.7	15	16	18	16	17	2.4	2.6	0.6	0.3	0.5	1760	1600	142	119	.292	
26						96	68	7	8	10																1920	1430	146	112	.292	.05
27						74	33	4	7	8	4.0	3.4	0.7	0.6	0.5											1790	1550	140	116	.293	.30
28																										1910	1560	141	115	.309	.05
29																														.275	
30	179	101	5	7	3	140	75	5	8	9						16	16	17	16	17	4.1	3.1	0.5	0.4	0.5	2150		167		.267	.15
31	206	150	9	8	4	212	80	8	3	11	5.6	4.4	0.2	0.2	0.4	16	19	19	18	18	2.9	3.5	0.4	0.5	0.5	2080	1380	163	138	.295	.05
AVE.	173	132	8	9	5	138	81	7	9	17	6.3	5.2	0.4	0.4	0.7	20	19	19	18	18	2.8	2.6	0.4	0.4	0.4	2330	1620	176	130	.289	
																										2400	2000	125	103	.333	

RS = Raw Sewage
PE = Primary Effluent
NT = North Tank
ST = South Tank
FE = Final Effluent

TABLE 12. Summary of Culver SBR Performance Data - April 1981

DATE	BOD_5 (mg/ℓ)					SUSPENDED SOLIDS (mg/ℓ)					PHOSPHORUS (mg/ℓ)					NH_3-N (mg/ℓ as N)					NO_x-N (mg/ℓ as N)					MLSS (mg/ℓ)		SVI (ml/g)		FLOW (MGD)	PPT (in)
	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	NT	ST	NT	ST		
1						126	73	8	7	9	5.1	5.0	0.5	0.5	0.7	16	17	17	19	18	2.1	2.0	0.3	0.3	0.5	2340		188		.263	
2						122	64	9	5	10	7.0	4.0	1.0	0.3	0.6		17	22	19	20	3.7	3.3	1.7	0.5	0.5	2120	1650	151	115	.264	
3						126	90	5	6	10																2220	1690	140	112	.309	0.5
4																														.275	
5																										2260	1620	142	99	.260	
6						102	90	7	8	16	5.3	5.0	0.6	0.4	0.7	17	19	22	19	19	3.4	5.5	0.1	2.0	0.2	2150	1490	144	114	.294	
7						186	96	6	9	14																2310	1610	147	106	.322	
8	225	160	13	11	10	104	63	14	8	23	6.8	4.5	0.8	0.6	0.8	21	23	22	22	22	1.7	1.8	0.1	0.2	0.2	2250	1920	169	109	.314	.35
9	204	124				199	76	7	10	13	5.1	4.4	0.5	1.6	0.5	16	19	29	19	19						1940	2030	188	123	.322	.45
10	284	143	9	18	5	214	69	8	34	10	7.3	4.5	0.3	1.0	0.4	30	24	21	19	20	3.0	1.4	0.2	0.3	0.2	2070	2140	401	126	.360	.45
11																														.322	.47
12						143	123	8	8	12	5.5	5.2	0.3	0.2	0.5	20	22	19	16	17	2.8	1.8	0.2	0.1	0.3	1950	1980	231	126	.323	1.20
13																										1890	2220	217	126	.635	2.65
14	72	62	7	7	13	124	86	6	9	45	2.1	2.3	0.3	0.5	1.3	4	4	7	6	10	1.8	1.5	0.5	0.3	0.1	2130	2240	211	125	.694	.05
15	93	35	6	5	6	128	48	4	6	36	5.5	3.1	0.3	0.5	1.3	8	7	9	6	6	3.0	2.5	0.3	0.5	0.4	2040	2200	172	105	.634	
16	272	65	11	6	6	744	70	17	4	14																2120	2290	142	96	.571	.03
17																										2570	2170	82	92	.517	
18																														.494	
19																										2250	2240	147	94	.466	.30
20						108	72	8	9	15																2080	2280	139	101	.506	
21						123	43	6	7	15																2130	2370	129	105	.491	
22	147	130	7	3	12	118	80	5	6	30																2050	1230	146	106	.494	.60
23	91	58	5	5	35	97	83	4	3	15	4.3	3.9	0.4	0.5	0.7	15	13	11	13	13	0.8	0.8	0.1	0.2	0.3	2140	1610	150	112	.479	.15
24	162	95	8	5	10	113	49	8	4	36																1780	1740	191	138	.479	.10
25																														.467	
26																											1800		150	.424	
27						89	70	4	13	46	5.6	4.4	1.1	0.5	1.5	20	19	13	21	14	1.8	2.0	0.1	0.6	0.2	2000	2170	393	203	.420	
28						92	68	17	76	18																3040	2800	301	154	.459	.85
29						136	74	7	40	54																2790	2320	253	125	.434	.10
30	153	106	6	21	7	139	64	7	22	33																2630	2360	133	108	.439	.10
AVG.	170	98	8	9	12	159	74	8	15	23	5.4	4.2	0.6	0.6	0.8	17	17	17	16	16	2.4	2.3	0.4	0.5	0.3	2210	2007	188	119	.424	

RS = Raw Sewage
PE = Primary Effluent
NT = North Tank
ST = South Tank
FE = Final Effluent

TABLE 13. Summary of Culver SBR Performance Data - May 1981

DATE	BOD_5 (mg/ℓ)					SUSPENDED SOLIDS (mg/ℓ)					PHOSPHORUS (mg/ℓ)					NH_3-N (mg/ℓ as N)					NO_x-N (mg/ℓ as N)					MLSS (mg/ℓ)		SVI (ml/g)		FLOW (MGD)	PPT (in)
	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	NT	ST	NT	ST		
1	160	120	8	18	16	125	64	9	20	57	5.4	4.7	0.8	0.8	1.3	20	18	14	14	15	1.7	2.6	0.3	1.0	0.6	2620	1490	153	107	.429	.10
2																														.405	
3																										2590	2360	151	97	.385	
4						157	72	4	6	15	9.2	8.0	0.2	0.3	0.2	23	22	15	16	16	0.3	0.3		0.1		2560	2610	168	84	.400	.05
5	190	101	5	7	3	114	77	4	6	4	7.5	7.8	2.4	2.5	2.3	19	20	18	18	18	2.5	2.3	0.3	0.6	0.6	2800	2760	118	91	.408	
6						104	83	4	5	17	6.2	5.0	2.5	2.4	3.5	19	19	18	18	18	2.3	2.4	0.2	0.3	0.3	3060	2980	111	81	.414	
7						134	77	8	14	24																2920	3030	120	89	.396	
8						120	68	4	10	17																3510	2740	120	91	.446	
9																														.378	1.90
10	115	115	15	17	15	110	72	8	10	15	4.1	3.5	0.7	0.5	0.8	20	21	16	17	17	1.5	1.6	0.1	0.3	0.3					.689	2.80
11																														.583	.15
12	103	75	14	5	1	118	70	5	8	12	5.0	5.0	1.1	0.6	1.0	8	11	14	13	14	1.0	1.4	0.2	0.2	0.2	2810	2460	111	108	.565	
13	148	120	4	3	1	91	100	5	8	14	3.8	3.4	0.4	0.3	0.6	19	19	9	11	9	2.1	4.4	0.3	0.1	0.4	2750	2800			.583	1.50
14																														.694	1.70
15	88	84	5	3	4	95	82	8	6	10	2.7	3.1	0.6	0.6	0.9	8	9	6	4	4	0.8	0.8	0.3	0.3	0.5	2330	2400			.728	.25
16																														.618	
17																														.593	
18						103	43	6	9	11	6.6	5.4	0.5	0.7	0.6	13	14	9	10	11	1.6	1.8	0.8	0.5	0.3	2620	2350	160	123	.597	
19	110	77	7	6	4	73	46	8	7	11	3.2	3.2	0.5	0.6	0.9	14	14	11	11	11	1.7	1.7	0.5	0.3	0.5	2730	2260	136	119	.571	
20	135	50	5	4	13	142	51	4	9	21	3.0	2.6	0.5	0.7	1.4	10	10	11	11	9	0.6	0.7	0.5	0.3	0.3	2420	2190	149	128	.527	
21						120	88	4	9	17	4.8	3.8	0.5	0.7	0.6	27	17	10	12	11	0.9	0.7	0.5	0.4	0.5	2120	2020	180	140	.531	
22						105	105	6	2	2	5.9	5.5			0.5	14	15			13	1.4	1.2			0.3	2450	2070	143	140	.572	
* 23																														.469	
* 24																											2600		196	.517	.70
* 25						82	44			4																			132	.490	
* 26						111	45			6	5.8	5.0			1.5	19	16			12	1.8	0.9			0.2		2590		193	.508	
* 27						55	39			5	3.3	4.0			0.6	16	15			13	1.1	1.1			0.2		2230		126	.485	.15
* 28	85	44			10	128	48			19	5.1	5.1			1.3	13	14			13	1.2	0.1					2440		102	.446	
* 29	70	40			16	87	42			9	3.3	3.3			1.0	11	12			9	1.0	2.7			2.5		2370		127	.502	.90
* 30																														.375	
* 31	178	38			17																						2870		174	.351	
AVG	126	79	8	8	9	109	66	6	9	15	5.0	4.6	0.9	0.9	1.1	16	16	13	13	13	1.4	1.6	0.4	0.4	0.5	2686	2458	140	122	.505	

* Microprocessor malfunction and switchover to TI unit.

RS = Raw Sewage
PE = Primary Effluent
NT = North Tank
ST = South Tank
FE = Final Effluent

TABLE 14. Summary of Culver SBR Performance Data - June 1981

DATE	BOD_5 (mg/ℓ)					SUSPENDED SOLIDS (mg/ℓ)					PHOSPHORUS (mg/ℓ)					NH_3-N (mg/ℓ as N)					NO_x-N (mg/ℓ as N)					MLSS (mg/ℓ)		SVI (ml/g)		FLOW (MGD)	PPT (in)
	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	NT	ST	NT	ST		
1						136	49			19																				
2	137	74			9	172	34			10	6.1	4.2			0.9	13	15			15	4.5	2.0			0.6	2660	2890	237	111	.362	
3						92	41			8	3.2	2.7			0.6	11	10			11	1.4	0.5			0.6	2500		120		.412	
4	98	80			10	73	48			10	3.0	2.7			0.8	9	9			9	0.8	0.5			0.6	2430		148		.421	
5	113	53			10	109	44			7	2.9	1.8			0.5											2630		133		.413	.50
6																										2480		141		.572	1.05
7																														.414	
8	71	69			8	68	60			8	3.0	2.1			0.6	10	17			5	2.3	1.8			0.7	1910		136		.379	
9						194	58			7	3.2	1.8			0.7	6	5				0.6	0.6			0.6	2560		207		.571	1.80
10																										2390		126		.535	.20
11	107	84			9	89	56			6	2.8	3.8			0.2	11	11			6	1.2	1.0			0.5	2420		128		.473	
12	153	62			11	156	49			6	5.6	3.5			0.6															.447	
13																										2380		118		.506	1.0
14																														.784	1.1
15						42	33																							.861	2.0
16						52	32			22																1920	1680	130	143	.814	2.5
17	112	65			8	196				9	3.4	1.8			0.7	8	7			<1	5.0	1.0			2.0	2420	2060	107	117	.739	
18	76	53			8	117	34			12						6	2			<1	1.0	0.8			2.0	1930	1550	124	158	.793	
19						46	31			12																2280	2210	105	104	.766	
20																										2080	2330	96	90	.795	
21																														.690	.25
22						84	42				2.2	2.1			0.5	6	5			<1	1.0	1.0			1.0	2850	1650			.730	1.85
23	118	90			8	244	151			6	4.0	3.3			0.5	7	7			<1	1.0	1.0			1.0	2420	1920	112	94	.851	
24						74	55			4	2.5	1.9			0.6	6	5			<1	0.5	0.5			1.4	3090	2510	78	72	.804	.10
25						285	92			8																2730	2710	114	89	.751	.65
26						147	58			3	3.3	2.1			0.4	7	5			4	0.5	0.4			2.5	2350	2240	132	121	.741	
27																										2590	2790	120	97	.713	
28																										2590	2370	127	127	.655	
29						311	47			6	6.8	2.4			0.8	14	10			0						2810	2600	146	100	.565	
30	130	77			6	135	49			4	4.3	2.9			0.4	13	11			<1						2610	2750	157	105	.614	
																										3480	3300	109	82	.593	
AVG	112	71			9	134	53			9	3.8	2.6			0.6	9	9				1.7	0.9			1.1	2500	2348	131	107	.626	

RS = Raw Sewage
PE = Primary Effluent
NT = North Tank
ST = South Tank
FE = Final Effluent

TABLE 15. Summary of Culver SBR Performance Data - July 1981

DATE	BOD_5 (mg/ℓ)					SUSPENDED SOLIDS (mg/ℓ)					PHOSPHORUS (mg/ℓ)					NH_3-N (mg/ℓ as N)					NO_x-N (mg/ℓ as N)					MLSS (mg/ℓ)		SVI (ml/g)		FLOW (MGD)	PPT (in)
	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	NT	ST	NT	ST		
1	124	68			4	235	64			3																					
2						143	72			6						13	12			1.0	1.2	3.1			7.7	2680	2650	175	113	.609	
3																										2840	2760	151	101	.615	
4																										2470	2160			.618	
5																														.520	
6						175	79			9																2480	2350			.571	
7						210	84			4	5.1	3.3			0.7	16	13			0.5	0.9	1.8			1.4	2710	2790	125	86	.560	
8						150	102			6	5.4	1.6			1.0	15	13			1.7	0.7	0.5			0.9		2570		101	.526	
9						168	57			4	5.3	4.2			1.5	14	11			0.3	1.1	1.3			1.8		2560		109	.537	
10						143	52			8						16	14			0.3	1.4	1.2			2.0		2410		87	.520	
11																											2490		76	.540	.50
12																														.468	
13						155	52			5	5.6	3.3			0.6	20	14			0.6	0.9	0.7			1.7		2470		65	.486	.15
14						208	31			4	5.2	2.5			0.9	12	13			0.8	1.0	1.0			1.5		2470		69	.515	
15	170	84			7	254	55			7	4.7	3.0			0.8	14	13			0.5	1.2	1.5			1.8		2280		68	.467	
16	177	92			6	258	41			8	6.3	2.6			0.8	20	12			0.1	1.0	1.0			2.4		2500		52	.506	.25
17	105	73			8	114	47			8	5.3	3.8			1.5	13	11			0.1	1.6	3.5			2.5		2670		52	.470	
18																											2200		61	.520	
19	212	124			6	146	46				6.3	3.9			0.8	16	14			0*	1.2	1.3			2.0					.489	.35
20	92	48			3	104	42			5	4.4	2.9			1.0	12	11			0	1.2	0.8			1.5	2740	3120		51	.607	1.40
21	164	49			6																					1780	3090	84	74	.638	.95
22	34	33			4	43	37			6																	3870	84	96	.582	.05
23	105	67			2	114	42			4	4.7	2.5			0.6	10	9			0	2.3	2.5			1.7		3680		79	.474	
24						74	43			5	3.8	3.6			0.9												3160		98	.487	
25																											3130		89	.527	
26																														.554	.85
27	157	111			10	202	63			5	5.4	4.1			0.4												3390		106	.498	.30
28	49	47			6	54	41			4	5.6	4.0			0.7	8	7			0	1.4	1.4			1.9		3500		167	.582	.35
29						93	51			7						17	17			0.5	1.2	1.0			2.0	1850	4040	108	223	.515	
30	146	93			7	154	72			6	5.5	3.3			0.1	17	15			1.8	1.1	0.9			1.7		3640		234	.525	
31						256	50			8	5.3	2.6			0.6	15	12			5.0	1.0	1.0			1.5	2310		91		.545	
AVG	128	74			6	157	56			6	5.2	3.3			0.8	15	12			0.8	1.2	1.4			2.1	2430	2890	117	99	.537	

*Zero values correspond to ≤ 0.05 mg/ℓ

RS = Raw Sewage
PE = Primary Effluent
NT = North Tank
ST = South Tank
FE = Final Effluent

TABLE 16. Summary of Culver SBR Performance Data - August 1981

DATE	BOD_5 (mg/ℓ)					SUSPENDED SOLIDS (mg/ℓ)					PHOSPHORUS (mg/ℓ)					NH_3-N (mg/ℓ as N)					NO_x-N (mg/ℓ as N)					MLSS (mg/ℓ)		SVI (mℓ/g)		FLOW (MGD)	PPT (in)
	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	NT	ST	NT	ST		
1																														.431	
2																										2490				.454	
3						79	28			3																2500		122		.465	
4						90	85			5	4.6	5.3			0.8	18	16			1.3	1.3	0.5			1.4	3180		116		.417	
5																										2830		118		.404	
6	127	79			4	122	80			5	5.7	6.3			0.8	19	15			0.5	1.7	1.5			2.0	2980				.368	
7																														.451	
8																														.390	.10
9																														.391	
10						131	67			7																3240		127		.433	
11	144	95			4	183	110			8																				.408	
12																														.409	
13	118	63			5	204	73			8																3380		98		.406	
14						252	72			9																2890		104		.505	.55
15																														.420	
16																										2850		109		.400	
17						95	58			12																2830		106		.416	
18	110	83			7	114	89			7	4.3	4.0			1.3	16	13			1.2	1.0	1.0			2.0	2700		93		.395	
19						170	61	2	11	14	6.2	4.4	1.1	2.2	1.3	20	14	0.1	3.0	2.0	2.5	2.6	2.0	2.7	2.7	2800		111		.387	
20						138	102	3	7	7	4.0	4.2	1.0	1.3	0.9	17	15	0.1	0.1	0.1	1.5	2.5	2.0	1.4	1.7	2890	2370	100	122	.400	
21	115	121	4	8	3	161	71	4	7	7	5.6	5.1	0.9	0.6	1.0	18	16	0.5	0.5	0.8	2.0	2.0	2.0	1.2	1.5	2710	2560	100	129	.401	
22																														.376	
23																										2660	2480	132	152	.359	
24						145	49	3	5	5	4.3	3.6	0.7	0.4	0.6	14	10	0.3	0.3	0.5	0.4	1.8	1.5	0.4	1.5	3070	2500	101	140	.379	
25						183	60	3	4	8																2700	2780	115	129	.385	.35
26	128	86	4	6	3	74	64	3	3	8	5.5	5.0	0.9	0.1	0.6	16	14	0.1	1.3	0.2	2.3	1.3	1.5	1.4	1.6	2670	2150	124	135	.438	.75
27	109	94	8	4	7	75	54	3	2	17	3.8	3.4	0.8	1.1	1.2	13	12	0.7	0.7	0.8	3.1	2.4	1.4	0.8	1.2	2640	2140	110	140	.391	1.10
28	84	58	5	8	3	44	42	2	3	7	5.0	4.2	0.8	0.8	0.7	14	12	0.1	0.1	0.1	1.5	1.1	1.3	1.1	1.5	2510	1930	112	140	.378	.05
29																										2870	2080	101	139	.362	.10
30																														.344	.25
31						98	54	4	2	9	6.6	4.8	0.9	0.9	0.8	15	13	0.1	0.1	0.1	1.6	1.2	1.7	0.8	1.3	2400	1900	113	142	.398	
AVG	117	85	5	7	5	131	68	3	5	8	5.1	4.6	0.9	0.9	0.9	16	14	0.3	0.8	0.7	1.7	1.6	1.7	1.2	1.7	2810	2290	111	137	.405	

RS = Raw Sewage
PE = Primary Effluent
NT = North Tank
ST = South Tank
FE = Final Effluent

TABLE 17. Summary of Culver SBR Performance Data - September 1981

DATE	BOD_5 (mg/ℓ)					SUSPENDED SOLIDS (mg/ℓ)					PHOSPHORUS (mg/ℓ)					NH_3-N (mg/ℓ as N)					NO_x-N (mg/ℓ as N)					MLSS (mg/ℓ)		SVI (mℓ/g)		FLOW (MGD)	PPT (in)
	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	NT	ST	NT	ST		
1						282	54	2	3	6	11.2	6.7	1.3	2.4	1.4	18	12	0.1	0.8	1.2	1.0	1.0	1.6	1.3	2.0	2660	1970	128	132	.403	.05
2	156	103	8	6	3	138	68	1	2	6	4.8	4.3	0.7	0.7	1.0	17	16	0.5	0.1	0.8	1.5	1.5	1.0	1.5	1.6	2560	2560	127	125	.396	
3						100	67	4	3	8	6.0	6.5	0.7	0.6	1.0	16	17	0.3	0.2	0.1	1.5	1.6	1.4	0.9	1.4	2480	2090	137	144	.486	.75
4						155	86	2	2	5	5.5	4.5	0.9	2.1	0.9	17	14	0.2	0.2	1.0	2.0	2.0	1.2	0.8	1.2	2850	2270	200	128	.483	
5																														.396	
6																		0.3	0.2				2.0	1.5		3100	2320	152	142	.430	
7																										2980	2260	144	124	.404	
8	178	120	7	4	2	130	60	3	1	5	7.2	5.0	0.8	0.8	0.7	23	17	0.2	0.2	0.2	2.4	2.4	1.4	1.5	1.4	3110	2130	132	131	.421	.50
9						104	56	2	3	6																3290	2210	195	122	.356	
10	102	95	6	3	2	110	63	4	2	7	4.4	4.5	0.4	0.6	0.6	13	16	0.5	1.0	1.1	1.0	1.3	1.3	1.6	1.6	3170	2120	148	137	.387	
11	168	103	3	3	2	187	71	3	3	7	6.0	2.8	0.4	0.4	0.4	28	25	3.8	4.1	4.3	3.9	6.2	2.3	3.1	2.4	2450	2170	139	129	.412	
12																														.349	
13																										2490		141		.323	
14						133	75	4	3	6	5.8	4.9	0.7	0.7	0.6	27	22	0.7	0.6	0.7	1.4	1.4	1.5	1.4	1.6	2540	2230	217	121	.355	
15						186	81	4	4	7	9.6	5.6	1.2	1.1	1.1	21	21	0.3	0.1	0.3	2.5	1.8	2.5	2.4	2.2	2530	2280	206	118	.340	
16						260	97	3	4	7	6.5	5.1	0.8	0.8	0.9	14	14	2.2	2.4	2.0	2.8	2.4	2.0	2.4	2.2	2580	2230	252	121	.367	.25
17	174	90	7	5	3	182	75	4	5	7	9.1	5.7	1.6	1.4	1.3											2580	2280	213	136	.349	.10
18	205	68	6	5	2	238	62	4	4	5	10.7	6.6	1.3	1.4	1.6	24	17	0.2	0.2	0.4	1.7	2.0	1.3	2.1	1.8	2630	2200	224	114	.333	
19																														.337	
20																											2490		137	.287	
21	155	114	5	5	2	127	63	3	4	9	7.1	5.0	0.6	0.6	1.1	24	19	0*	0	0	1.3	1.7	1.8	1.2	1.8	2830	2510	272	120	.327	
22						127	56	3	6	6						24	17	0.2	0.2	0.5	1.6	3.7	2.0	1.6	2.0	3240	2350	225	119	.366	
23						268	58	2	3	7	6.8	5.7	1.4	0.9	1.2	16	14	0	0	0	1.8	2.2	2.2	1.4	2.0	3060	2450	235	165	.353	.10
24																														.360	
25																											2250			.390	
26																														.408	1.65
27																										3150	2670	200	146	.393	
28	238	142	8	8	10	148	78	3	3	6	10.5	8.2	0.9	0.5	1.1	24	21	0.2	0.6	1.4	2.5	2.0	1.0	1.5	1.2	2670	2670	285	180	.387	.50
29						117	80	2	4	8	4.9	5.3	0.6	0.7	0.8	22	18	3.3	0.6	1.6	2.1	2.4	1.4	1.8	2.1	2580	2720	217	143	.441	.35
30						173	97	3	1	6	6.3	8.6	0.9	1.1	1.3	15	13	0.4	0.2	1.0	1.2	1.0	0.9	0.8	0.8	2650	2720	181	125	.366	
AVE	172	104	6	5	3	167	71	3	3	7	7.2	5.6	0.8	1.0	1.0	20	17	0.8	0.7	1.0	1.9	2.2	1.6	1.6	1.7	2790	2340	190	133	.351	

*Zero values correspond to ≤ 0.05 mg/ℓ

RS = Raw Sewage
PE = Primary Effluent
NT = North Tank
ST = South Tank
FE = Final Effluent

TABLE 18. Summary of Culver SBR Performance Data - October 1981

DATE	BOD_5 (mg/ℓ)					SUSPENDED SOLIDS (mg/ℓ)					PHOSPHORUS (mg/ℓ)					NH_3-N (mg/ℓ as N)					NO_x-N (mg/ℓ as N)					MLSS (mg/ℓ)		SVI (mg/ℓ)		FLOW (MGD)	PPT (in)
	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	NT	ST	NT	ST		
1						216	105	9	26	22			1.1	2.5	1.8	22	22	12[4]	15[4]	12[4]	3.6	4.2	0.4	1.0	0.5	2850	3150	179	102	.390	.35
2	194	100	9	11	6	264	87	20	16	26	10.0	8.0	1.3	1.1	1.3	20	19	18[4]	18[4]	18[4]	1.6	1.4	0.5	0.5	0.5	3000	3390	143	115	.393	.10
3																														.331	
4	229	120	13	14	3	111	63	7	10	16	6.8	5.7	0.9	0.8	1.1	29	26	1.2	8.4[4]	6.5	2.5	1.5	1.2	0.5	0.8	2870	2900	237	112	.365	
5	142	125	11	15	5	124	143	13	9	24	5.3	5.3	1.4	0.9	0.9	22	20	1.0	7.0[4]	4.0	4.0	4.0	2.0	0.7	1.2	3170	3660	259	145	.389	.55
6	162	95	16	10	6	152	76	4	3	32	5.8	5.0	0.7	0.6	1.9	22	18	6.3	2.0	4.0	2.2	2.5	0.4	0.7	0.9	3220	3430	214	163	.377	
7	144	81	12	8	4	159	57	6	1	28	6.2	5.0	0.7	0.3	1.0	21	18	2.0	0.2	1.8	1.5	2.0	0.8	1.7	1.3	3220	3450	208	136	.361	
8						210	85	3	2	13	4.7	4.3	0.6	0.6	0.6	18	18	0.1	0.2	0.4	2.5	3.2	1.4	1.5	1.0	3290	3330	213	150	.360	
9	75	82	6	7	6	137	78	2	2	8	6.9	5.0	0.7	0.7	0.6	20	17	0.5	0.5	2.0	1.5	2.6	1.2	1.0	1.5	3190	3460	207	153	.403	
10																														.387	
11																														.336	
12						132	67	2	7	14																3340	4140	198	123	.392	
13								8																		2960	2940	203	119	.386	
14	83	84	5	8	1	187	63	2	5	6	3.8	4.2	0.3	0.4	0.4	16	17	0.1	0.8	1.5	0.8	1.4	0.8	1.4	0.5	2760	3130	196	121	.356	.30
15	64	70	7	5	2	139	54	2	4	4	3.3	3.4	0.4	0.4	0.4	15	14	0	0	0	3.4	1.3	0.8	0.8	0.8	2820	2660	167	120	.380	.15
16						162	74	3	2	7																				.399	
17																														.425	.50
18	74	99	12	8	2	135	60	3	3	7	6.2	4.9	0.3	0.3	0.4	17	14	0	0	0	3.0	1.3	0.8	0.7	0.8	2220	2850	225	130	.338	.10
19						71	37	4	2	5	4.8	3.5	0.3	0.3	0.4	14	17	0	0	0	0.6	0.7	0.6	0.7	0.8	2420	2500	207	136	.382	
20	144	61	7	6	3	136	54	3	4	5	7.5	4.7	0.3	0.3	0.3	15	14	0	0	0	1.0	1.5	0.7	0.6	0.8	2550	2610	180	138	.373	
21						148	62	5	5	6																2310	2440	182	143	.361	.15
22	214	134	6	7	4	154	100	2	2	5	6.7	4.5	0.5	0.9	0.5	20	17	0	0	0	2.0	1.1	1.0	1.0	1.0	2510	2520	155	131	.394	.15
23						157	69	9	4	9																2660	2580	132	124	.412	
24																														.360	
25																															
26						182	93	4	10	4	7.1	5.9	0.4	0.7	0.7	24	23	6.0	0.5	3.0	1.5	2.2	0.8	1.5	1.3	2660	2540	162	142	.387	.40
27	232	140	18	8	11	156	101	10	3	9	5.1	4.3	0.6	0.6	0.4	26	25	2.2	0.2	1.0	1.5	1.6	1.6	1.6	1.2	2820	2500	174	156	.388	.05
28						120	77	3	4	11	5.8	4.8	0.2	0.5	0.6											2530	2580	134	128	.355	
29	256	191	12	21	7	150	92	8	7	12	5.8	5.4	0.3	0.7	0.6	23	22	0.1	3.8	2.1	2.2	2.0	1.0	1.4	1.3	2700	2700	156	123	.374	
30	267	185	22	9	4	202	98	15	4	7	7.1	5.3	0.9	0.6	0.4	24	21	2.0	0.1	3.0	4.6	4.4	1.6	1.6	1.4	2740	2940	131	129	.416	
31																														.189	
AVG	163	112	11	9.8	3.6	157	76	6.1	5.9	12.2	6.1	5.0	0.6	0.7	0.8	19.2	19.1	1.4	0.6	1.8	2.2	2.2	1.0	1.1	1.0	2689	2954	188	132	.377	2.8[11]

[4] Not included in final average

[11] Total for month

RS = Raw Sewage
PE = Primary Effluent
NT = North Tank
ST = South Tank
FE = Final Effluent

TABLE 19. Summary of Culver SBR Performance Data - November 1981

DATE	BOD_5 (mg/ℓ)					SUSPENDED SOLIDS (mg/ℓ)					PHOSPHORUS (mg/ℓ)					NH_3-N (mg/ℓ as N)					NO_x-N (mg/ℓ as N)					MLSS (mg/ℓ)		SVI (mℓ/g)		FLOW (MGD)	PPT (in)
	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	RS	PE	NT	ST	FE	NT	ST	NT	ST		
1																															
2	255	206	11	14	2	202	92	7	7	8	7.1	6.3	0.5	1.3	0.8	23	21	0.8	2.0	2.0	2.0	1.8	0.8	1.4	1.4	2700	2580	141	128	.394	.10
3	154	126	22	9	4	150	92	15	6	10	7.3	5.3	0.8	0.2	0.5	26	23	2.0	0.1	0.9	1.2	1.1	1.0	1.2	1.0	2810	2540	139	122	.351	.05
4	122	120	9	14	4	116	66	5	4	7	5.8	5.1	0.3	0.6	0.6	21	19	0.2	2.0	1.1	2.2	2.1	1.5	2.0	1.6	2700	2540	222	126	.314	1.50
5	194	127	40	8	4	156	96	39	4	8	6.6	4.7	2.1	0.6	0.4	24	21	4.5	0.1	1.8	2.6	2.1	1.2	1.2	1.0	2650	2720	151	118	.354	.20
6	204	137	19	11	6	166	90	21	7	8	7.5	6.0	0.8	0.5	0.6	25	22	0.1	1.0	0.4	2.4	2.0	1.0	1.2	1.0	2950	2440	136	107	.385	
7																														.351	
8																															
9						116	92	16	4	9	8.6	6.6	0.4	0.2	0.4	22	20	1.7	0.4	0.2	1.9	1.3	1.0	0.8	0.9	2910	2130	151	108	.359	
10	214	114		11	20	152	108	12	5	12	6.8	4.4	0.9	0.9	0.8	21	19	1.5	0.5	0.1						2770	2160	130	93	.357	
11	76	134	12	6	8	64	98	7	4	11	4.1	5.8	0.3	0.3	0.6	17	16	0.1	0.1	0.1	5.0	4.2	1.7	1.0	1.2	2720	2420	123	103	.299	
12	143	79		9	10	120	72		5	12	6.1	4.4	0.9	0.9	0.9	25	20		0.5	0.5	12.0	2.7		0.8	1.0	2750	1970	120	96	.321	
13																														.333	
14																														.289	
15	245	134	9	13	11	147	71	6	11	14	12.3	7.4	0.2	0.8	0.5	24	22	6.0	0.2	2.7	1.3	1.1	0.4	1.3	0.9	3300	1710	91	146	.309	
16	132	137	8	2	3	128	92	5	3	12	5.8	4.8	0.5	0.2	0.5	24	22	3.4	0.5	0.6	2.0	2.2	1.3	1.0	1.0	2500	2230	120	121	.335	
17	157	89	7	7	9	260	116	3	4	12	7.2	5.0	0.4	0.3	0.6	19	18	0.5	0.5	2.0	2.3	1.8	1.3	1.2	1.3	2500	2120	120	103	.347	
18	151	103	8	8	8	188	120	3	4	11	8.3	6.6	0.5	0.6	0.7	20	18	0.4	0.4	0.5	1.5	1.6	1.3	1.3	1.3	2520	2260	107	106	.228	.20
19																										2630	2030	122	103	.366	1.40
20						236	85	5	6	12	7.3	6.8	0.6	0.8	0.8	22	21	1.0	0.4	0.5	1.7	1.3	1.2	1.4	1.2	2730	2270	114	93	.400	.20
21																														.321	.80
22																														.334	
23						196	103	9	8	8	6.2	5.4	0.8	0.9	0.9	24	21	1.4	0.6	0.9	1.6	1.4	1.4	1.0	1.1	2680	2240	108	125	.389	.55
24	178	130	8	11	10	169	93	4	7	7	6.3	5.3	0.2	0.8	0.7	24	21	0.2	0.8	0.6	1.2	1.1	1.2	1.7	1.4	2680	2410	127	91	.395	
25	165	115	13	23	18	304	127	4	6	11	7.5	5.0	0.7	1.1	0.5	21	19	0.6	0.7	0.5	1.4	1.0	1.2	1.4	1.2	3040	2440	141	98	.375	
26						190	88	5	6	12	5.0	4.1	0.7	0.8	0.5											2900	2320	128	91	.298	.10
27																														.328	
28																														.264	
29						122	98	13	2	7	5.2	4.5	1.0	0.5	0.9	23	20	5.6	1.4	3.4										.310	
30						153	117	4	8	7	8.0	5.1	0.6	1.1	0.6											3270	2660	211	120	.374	.20
AVG	171	125	14	10	8.4	167	96	9.6	5.6	9.3	7.0	5.4	0.7	0.7	0.6	22.5	20.2	1.7	0.7	1.0	2.6	1.8	1.2	1.2	1.2	2794	2351	137	110	.331	5.05[1]

[1] Total for month

RS = Raw Sewage
PE = Primary Effluent
NT = North Tank
ST = South Tank
FE = Final Effluent

TABLE 20. Summary of Culver SBR Performance Data - December 1981

DATE	BOD_5 (mg/ℓ)					SUSPENDED SOLIDS (mg/ℓ)					PHOSPHORUS (mg/ℓ)					NH_3-N (mg/ℓ as N)					NO_x-N (mg/ℓ as N)					MLSS (mg/ℓ)		SVI (mg/ℓ)		FLOW (MGD)	PPT (in)
	RS	PE	NI	ST	FE	RS	PE	NI	ST	FE	RS	PE	NI	ST	FE	RS	PE	NI	ST	FE	RS	PE	NI	ST	FE	NI	ST	NI	ST		
1	195	139	8	11	12	137	90	6	8	11	5.5	5.8	0.6	0.7	0.6	19	18	0.2	0.5	1.0	1.9	2.7	1.3	2.7	1.7	3130	2160	160	92	.336	.10
2	112	145	9	11	11	104	106	4	6	16	5.5	5.0	0.6	0.5	0.6	18	16	0.5	0.4	0.4	1.2	1.1	1.2	1.6	1.3	3260	2670	196	112	.406	
3	161	129	10	7	10	138	84	5	4	14	9.4	5.9	0.4	0.5	0.6	22	20	1.0	0.1	0.7	1.5	2.5	1.8	0.9	1.2	2800	2340	136	98	.329	.20
4	135	94	6	5	5	152	85	2	6	6	11.1	6.4	0.6	0.6	0.4	21	19	1.2	0.4	0.8	1.8	2.0	1.2	1.0	1.4	2850	2350	131	89	.375	.10
5																														.355	
6																										2830	2620	145	95	.294	
7	161	159	9	26	11	164	93	4	11	11	7.0	5.5	0.5	2.2	0.8	23	20	1.0	2.4	1.4	1.5	16	1.5	0.9	1.1	2920	2310	164	108	.348	
8	217	191	10	12	9	176	149	5	4	4	9.3	7.8	0.3	0.7	0.5	21	17	0.2	1.0	0.9	1.2	1.5	1.5	1.1	1.2	2950	2460	122	89	.346	.15
9	225	114	10	13	9	167	142	8	8	9	6.2	5.4	0.5	0.8	0.7	19		0.9	1.8	1.3	1.7		1.3	2.2	1.2	2920	2630	157	95	.304	.10
10	257	94	13	8	11	105	96	8	10	8	7.6	5.1	0.7	0.5	0.6	21	19	0.5	1.5	1.1	1.2	1.1	1.0	1.5	1.2	3310	2320	127	93	.349	.05
11	218	160	12	23	15	194	152	7	12	11	8.5	5.0	0.5	0.8	0.5											3190	2510	122	96	.357	
12																														.290	
13																										3120	2330	122	94	.319	
14						145	70	9	18	19	8.9	7.3	0.8	1.8	1.3	23	19	2.7	8.6	3.9	1.7	1.4	1.5	0.5	1.0	3140	2170	120	97	.344	
15	160	140	21	6	15	149	107	9	3	16	9.7	7.8	0.7	0.7	0.6											3160	2140	111	84	.318	
16	218	140	16	9	11	177	78	7	4	8	11.5	7.5	0.8	0.7	0.4	20	21	0.9	0.3	0.4	2.0	2.2	2.6	1.5	1.8	3150	2050	111	78	.289	.30
17	200	191	14	17	13	135	96	8	6	10	6.4	5.9	0.6	0.6	0.4	17	14	0.2	3.0	1.8	1.3	1.5	1.4	3.0	2.0	3260	2290	126	92	.326	
18	163	155	19	7	14	114	127	10	5	9	5.8	6.0	0.8	0.2	0.6											3100	2400	119	88	.388	
19																														.274	
20																										3280	2130	162	85	.255	
21	107	120	15	26	17	110	84	4	16	16	10.8	6.5	0.4	3.3	2.7	19	18	3.9	9.0	5.5	2.2	2.6	1.6	0.9	1.0	3370	1950	128	97	.289	.10
22	185	126	11	13	12	161	97	8	9	15	8.9	4.8	0.6	0.6	0.4	14	13	0.3	0.5	0.5	1.9	2.0	1.5	1.0	1.0	3350	3110	110	64	.267	.20
23	153	118	10	10	11	98	64	3	7	12	6.3	5.5	0.6	0.6	0.5	19	16	0.5	0.6	0.5	2.3	1.8	1.0	2.3	1.6	3430	2480	108	77	.271	
24						105	73	7	10	9						21	18	0.4	0.6	0.4	1.2	1.8	1.3	1.5	2.0	2840	2420	106	74	.255	
25	135	80	13	8	10	98	84	9	7	11						20	17	0.2	0.2	0.1	2.0	1.6	2.1	1.1	1.4	3190	2310	116	91	.269	
26																														.253	.43
27																											2710		96	.266	
28						98	58	5	8	15	6.6	4.9	0.5	0.7	0.8	17	16	1.0	0.9	1.0	1.6	1.2	1.2	1.5	2.6	3070	2610	114	93	.301	
29	155	88	10	8	10	110	73	7	3	12	9.2	5.1	0.7	0.6	0.7	18	16	0.4	0.4	0.6	1.8	2.0	1.8	1.3	1.7	2980	2670	111	90	.274	.25
30	260	77	6	19	10	96	47	6	5	10	12.3	4.8	0.4	1.0	0.7	25	19	0.2	3.5	2.8	1.3	1.7	0.9	0.8	0.9	2970	2310	88	78	.271	
31						90		5	5		6.7		0.7	0.8		20		0.5	2.5		1.2		0.7	1.1		2910	2930	110	58	.290	
AVG	180	123	12	13	11	131	93	6.3	7.7	11.5	8.2	5.9	0.6	0.9	0.9	19.9	17.6	0.9	1.9	1.3	1.6	1.8	1.2	1.4	1.4	3101	2429	129	89	.300	2.0 †

†Total for month

RS = Raw Sewage
PE = Primary Effluent
NI = North Tank
SI = South Tank
FE = Final Effluent